

W. E. G. L.

BULLETIN

of the

American Association of Petroleum Geologists

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BULLETIN

of the

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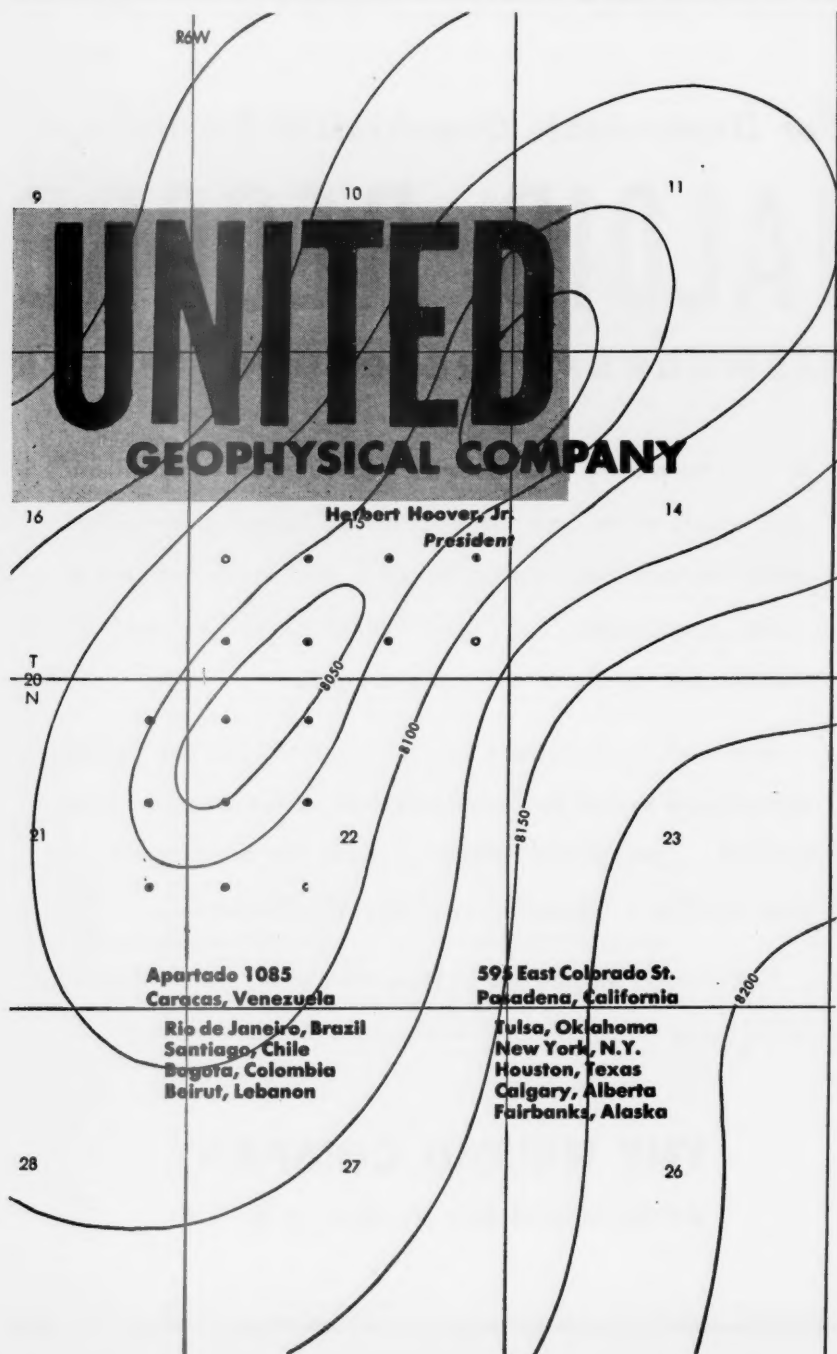
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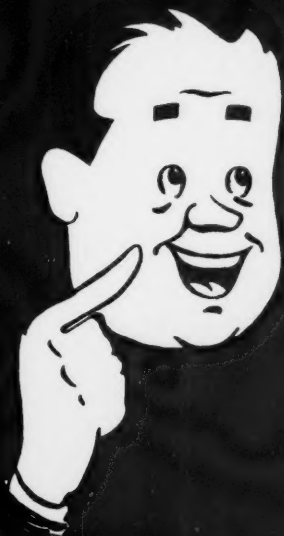
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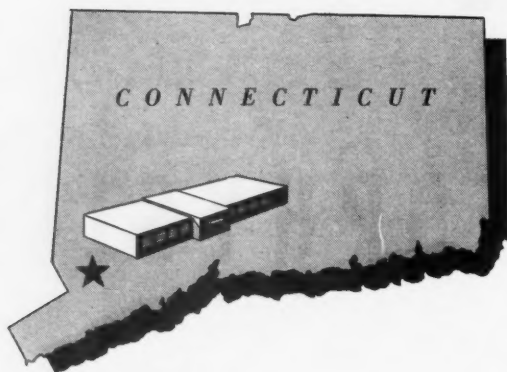
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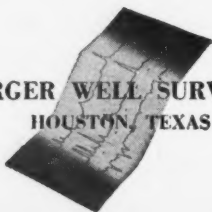
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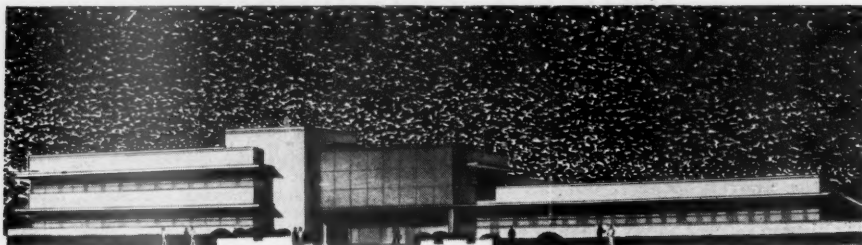
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BULLETIN
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**AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS**

DECEMBER, 1948

**FERNVALE AND VIOLA LIMESTONES OF SOUTH-
CENTRAL OKLAHOMA¹**

SHERMAN A. WENGERD²

Albuquerque, New Mexico

ABSTRACT

The Fernvale and Viola limestones of south-central Oklahoma are exposed in the Arbuckle and Wichita mountains, and are found in the subsurface in much of the Mid-Continent region. Fernvale (Richmond) and Viola (Trenton) strata are chiefly limestone with varying amounts of chert, dolomite, detrital quartz sand, and minor sedimentary constituents.

Isopachous and lithologic characteristics of these Ordovician formations indicate* that the strata were deposited in the northwest-trending Arbuckle geosyncline having a broad platform in the Seminole area. The Fernvale limestone is thickest in a northwesterly trend extending from the Wapanucka graben to the Pauls Valley anticline, whereas the Viola limestone is thickest in a northwesterly trend approximately parallel and corresponding with the zone of maximum sedimentation in pre-Viola basins of deposition in the Arbuckle geosyncline.

The Fernvale limestone contains abundant detrital quartz sand where thickest and the crystallinity ranges from very coarse on the platform to medium in the basin. The Viola limestone is predominantly dolomitic on the platform, cherty on the platform slope, and siliceous in the basin. Fernvale and lower Viola limestones are essentially planar-bedded in the area of maximum deposition, whereas the upper and middle Viola beds are irregularly bedded in most of south-central Oklahoma.

Regionally correlatable lithologic characteristics of the Viola limestone indicate that the formation is divisible into four principal members of which the uppermost and the lowermost wedge out north-eastward from the basin to the platform. With a few local exceptions, such as the Franks and Wapanucka grabens, all members of the Viola limestone thicken regularly from the platform to the basin.

The Viola limestone of the Arbuckle facies is areally divisible into six sub-facies to which the following names are applied: Seminole, McAlester, Fitts, Wapanucka, Tishomingo, and Ardmore. Though there are significant differences in Viola sections of the six stratigraphic provinces, their boundaries are gradational and any suite of Viola cuttings or surface samples may be assigned to its correct province through lithologic characteristics alone, without the aid of specific location on a map.

¹ Manuscript received, July 31, 1948. Manuscript edited in part from a Doctoral thesis presented at Harvard University on April 27, 1947.

² Associate professor of geology, University of New Mexico; formerly research geologist for Shell Oil Company, Inc. The writer is indebted to Richard V. Hollingsworth, Roscoe E. Shutt, and Erik Waering, formerly of the Shell Oil Company, for making the subsurface samples available and for guidance in this study. Florence Wengerd skillfully prepared the residues, aided in field work and gave encouragement in the arduous phases of the work. Special lithologic examination by Ralph E. Grim, Clarence S. Ross, and Professor Esper Larsen, Jr., resulted in the identification of some peculiar but normal lithologic types in the Viola limestone. Charles E. Decker kindly gave advice, counsel, and references to the literature. Professor Kirtley F. Mather gave unstintingly of his time in revision of the manuscript and in guidance during its initial preparation. Glenn Peacock and T. Owen Savage prepared the illustrations and the Senate Research Committee of the University of New Mexico provided funds for the final preparation of the manuscript and illustrations.

COMPOSITE

STRATIGRAPHIC DIAGRAM

SCHEMATIC GENERALIZATION SHOWING RELATION OF VIOLA LIMESTONE AND REGIONAL EROSION

OF VIOLA LIMESTONE AND REGIONAL EROSION SURFACES.

SURFACES.
ECCENTRIC CYLINDRICAL BEARING SURFACES

EROSION SURFACE RESULTING FROM EPIEROGENY

EROSION SURFACE RESULTING FROM LOCAL AND REGIONAL CORROSION

REGIONAL OROGENY

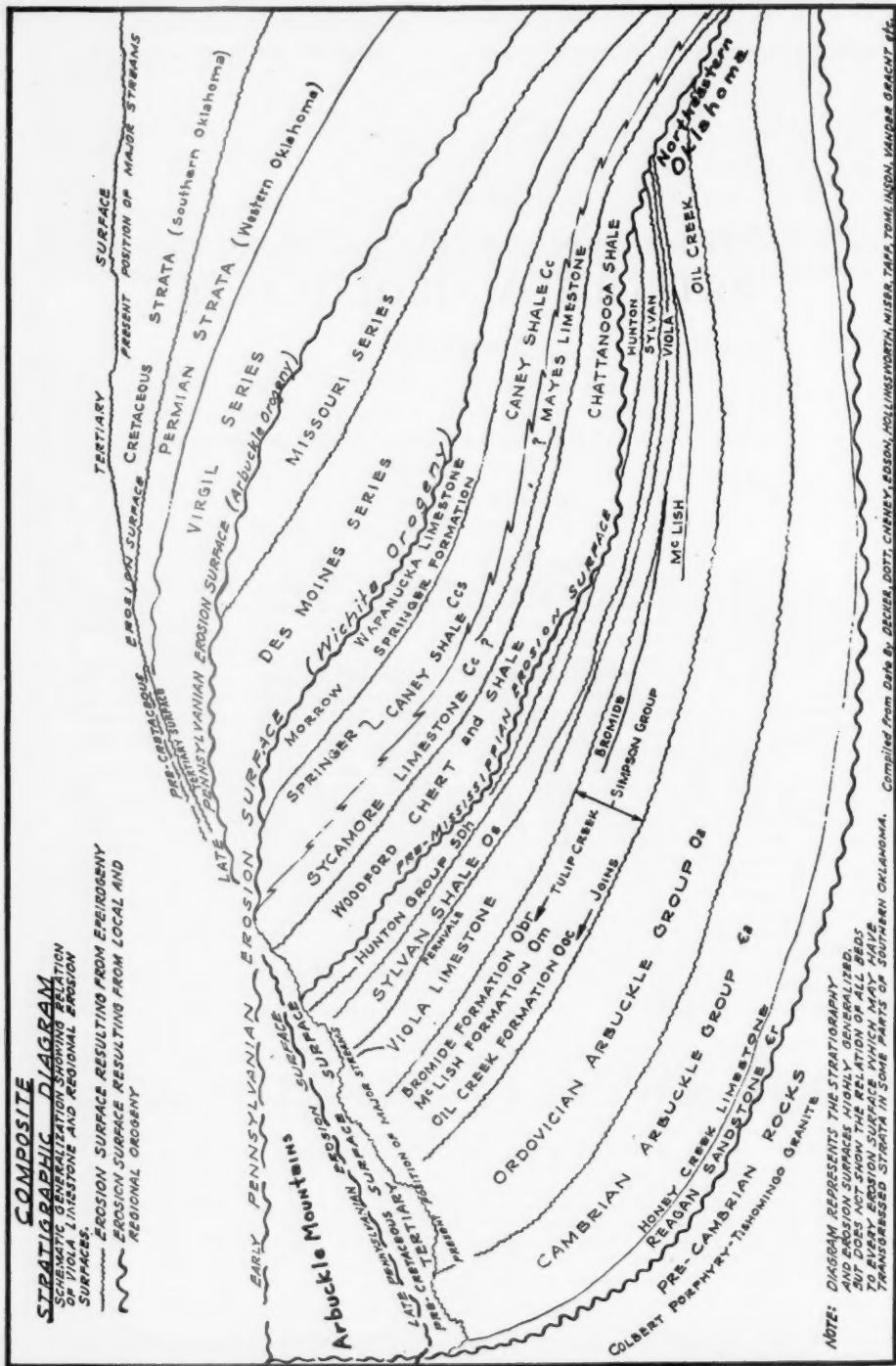


FIG. 1.—Composite stratigraphic diagram of south-central Oklahoma.

Isopachous studies of the Fernvale and Viola limestones show that the orogenies which caused the folds and faults of the Arbuckle Mountains, and adjacent subsurface anomalies, had no effect upon the original Fernvale-Viola basins during the deposition of those strata.

The significant lack of correlation between Viola production and maximum intercrystalline porosity, or location of the wedge-edges of the members, suggests that productive Viola reservoirs are present in localities of fortuitous orogenic shattering rather than in broad areas where maximum porosity may occur because of lithogenesis of the carbonate sediments.

INTRODUCTION

GEOGRAPHIC OCCURRENCE

The Fernvale and Viola formations comprise those Ordovician Richmond and Trenton limestones below the Sylvan shale and above the Simpson group in south-central Oklahoma. These limestones are excellently exposed as a distinctive lithologic unit in the Arbuckle and Wichita mountains, and they are present in wide areas of the Mid-Continent region where extensive drilling has yielded subsurface samples for geologic study. Viola beds have been found in the subsurface as far north as South Dakota, southward in Texas, and westward in Colorado. The top of the distinctive Fernvale limestone is utilized as a key horizon in subsurface mapping of deep tests in the Mid-Continent region.

STRATIGRAPHIC POSITION

The Fernvale and Viola limestones, themselves productive of petroleum in isolated areas of the Mid-Continent, occupy a critical stratigraphic position between the productive Siluro-Devonian Hunton limestone and the highly productive sandstones of the Bromide and McLish formations in the Simpson group (Fig. 1). The sharp contact of the Fernvale limestone with the Sylvan shale above is easily ascertained in drill cuttings, and the apparent synchronicity of the Fernvale-Sylvan interface over wide areas validates this key horizon for regional and local mapping of subsurface structure. Of greater importance are the geological factors connected with the genesis of the Arbuckle geosyncline as reflected by thickness and lithologic character of the Fernvale and Viola limestones. These formations are therefore of special interest to petroleum geologists in the Mid-Continent region, and their lithologic subdivisions pose problems of significance to students of the ancient sediments.

LOCATION OF AREA OF STUDY

The area of study embraces the Arbuckle Mountains, the northwesterly extension known as the Pauls Valley uplift, the Seminole uplift on the northeast, the southeast extension to the Ouachita front, and a part of the Ardmore basin on the southwest. The study is thus limited to an area of 4,000 square miles in south-central Oklahoma where abundant subsurface and surface data are available (Fig. 2).

PURPOSE OF STUDY

Fernvale and Viola strata were studied to obtain valid lithologic subdivisions of regional extent, for they contain notable vertical and lateral variations. Though

these strata are predominantly of limestone, they contain chert, dolomite, shale, and minor amounts of disseminated clay and sand, as well as lesser constituents.

It is now evident that Fernvale and Viola sediments were deposited in shallow epeiric seas occupying a relatively small but deep northwest-trending basin paralleling a submerged shelf on the northeast in the Seminole area, from which the sea floor sloped southwestward into the deeper part of the Arbuckle geosyncline. Under these conditions, the Fernvale and Viola beds present a peculiarly favorable opportunity for the study of important sedimentation problems related to basin and shelf facies in limestone strata. The following questions are

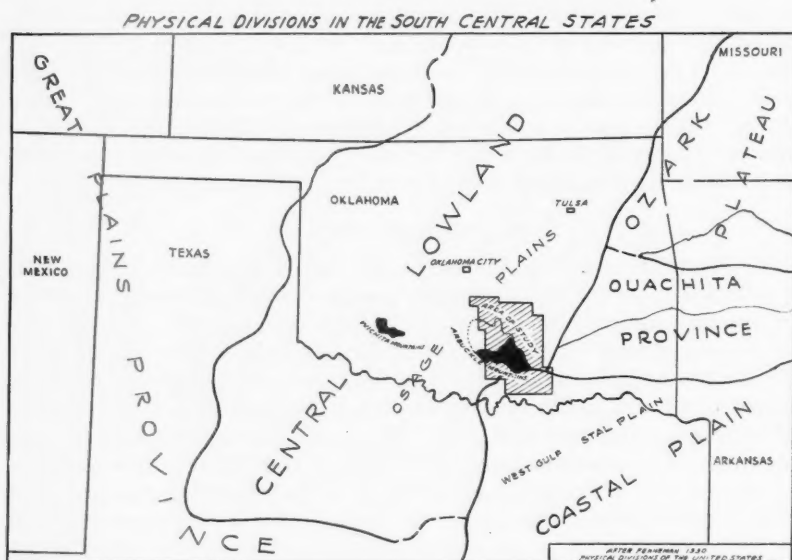


FIG. 2.—Location of area of study.

especially pertinent: (1) do the rocks contain discernible lithologic records of hiatuses of disconformic rank?; (2) are there notable differences between rocks now exposed, or equivalent rocks exposed because of Pennsylvanian erosion, and correlative strata which have not been exposed to subaerial conditions since late Ordovician time?; (3) how successfully can intra-formational correlations be made between the surface and the subsurface?; (4) what are the sedimentational relations of a shelf and a basin in an epeiric sea? The search for answers to these questions has led to this study of the middle and late Ordovician strata in south-central Oklahoma.

SOURCES OF DATA

Field studies of the Fernvale and Viola formations involved the collection of 900 samples from approximately 3,700 feet of section in six separate localities. Fifty-six hundred subsurface samples, representing a total section of 32,000 feet, were gained from 117 drilled tests. Insoluble residues were prepared from 2,500 field and subsurface samples. Forty-five thin sections were prepared of typical Fernvale and Viola specimens, including cores, in order to study the complex petrogenesis of these beds.

METHODS OF INVESTIGATION

Field studies were facilitated by aerial photographic interpretations of the characteristic Fernvale-Viola outcrop. Detailed field measurements and descriptions were made during sample collections at the six field localities, generally along road and stream cuts. Field logs were constructed as measurement proceeded, and field specimens were later examined under the binocular microscope in the laboratory.

Detailed laboratory logs resulted from petrographic and petrologic studies of surface samples, subsurface samples, and their insoluble residues. The logs were constructed at a scale of 1 inch equals 10 feet, and the detailed descriptions were made in accordance with standards of description as shown in Figure 3.

Correlation of these logs and lithologic subdivision of the limestone section were completed by replotting the logs from the best subsurface and surface sections into regional lithologic cross sections at a vertical scale of 1 inch to 20 feet. The position of regional stratigraphic cross sections constructed from these detailed lithologic cross sections is shown in Figure 4. Quantitative data were placed on maps and contoured, in an effort to determine the stratigraphic and gradational lithologic characteristics of the Fernvale and Viola limestones.

REVIEW OF PREVIOUS INVESTIGATIONS

Review of previous work by numerous investigators may be divided into two sections: previous studies of the Fernvale and Viola limestones, and those regional studies prerequisite to an understanding of Mid-Continent geology.

FERNVALE-VIOLA STUDIES

Joseph A. Taff first described the Viola limestone from a prominent outcrop near the village of Viola in Johnston County, Oklahoma (Taff, 1902, p. 3). Ulrich identified the Viola fossils collected by Taff, and the correlation of field work and fossil identifications resulted in a tentative three-fold division of the formation. On the basis of these studies, which include strata now recognized as the Fernvale and Viola formations, Taff stated that the Viola beds were deposited during the Trenton, Utica, Frankfort, Lorraine, and Richmond epochs as then recognized in the New York section (Taff, 1903, p. 4). On the basis of Ulrich's revised fossil lists, Taff stated that the lowest member, approximately 100 feet thick, is latest Black

[illegible]

Fig. 3.

River and earliest Trenton in age; the top member, approximately 300 feet thick and containing fossils only in the upper 50 feet, is Richmond in age (Taff, 1928, pp. 22-25).

A more recent paleontologic analysis of the Viola limestone was made by Decker, who collected fossils from 15 sections which he measured in the Wichita, Arbuckle, and Ouachita mountains. Decker, despite much additional evidence gained from road cuts not available during Taff's work, stated that the age correlations made by Taff 30 years previously "... seem to hold at present" (Decker, 1933, p. 1415).

The detailed paleontological work by Decker on the Viola limestone was preceded by descriptions and subdivision of the Simpson (Decker, 1930, and Decker and Merritt, 1931). This work, plus that by Ulrich in 1927, led to a critical definition of the Viola-Bromide contact which proved that Taff had originally defined the base of the Viola limestone 200 feet too low in the section, that is, including some Simpson beds now considered to be Bromide in age (Edson, 1927, pp. 967-75). Decker's work on the Viola limestone proved the extensive distribution of these strata by correlating discontinuous outcrops in a wide area, and he considered, just as Taff did, that the Fernvale and Viola limestones were one formation (Decker, 1933, p. 1433).

Ulrich published his "Revision of the Paleozoic System" in 1911, based in part on sections exposed in the Arbuckle and Ozark mountains. Ulrich's later work led to some confusion concerning the age and classification of the Viola limestone (Wilmarth, 1938, p. 2252), as reported by Fanny Carter Edson in a review of his unpublished memoranda and published data (Edson, 1935, p. 1127). Ulrich's paleontologic-stratigraphic subdivisions did, however, point the way for later investigations, and he recognized the correlation of the Richmond limestone in Oklahoma with the Fernvale limestone at the type locality in Tennessee (Edson, 1935, pp. 1110-30).

Aside from the unpublished generalized studies of the Viola limestone by John Fitts, and the insoluble-residue work done by Ireland, little has been published on the specific lithologic characteristics of those strata. Ireland recognized the need for more careful correlation of surface outcrops with subsurface sections and applied McQueen's insoluble residue technique to determine masked characteristics of the section from the Hunton limestone to the Bromide limestone of the Simpson group (Ireland, 1936, p. 1087).

The major subdivision, made by most commercial Mid-Continent stratigraphers, separated the Richmond Fernvale limestone above, from the Trenton Viola limestone below,³ and a parallel unconformity of regional extent is now recognized between the two formations.

Edson recognized the regional disconformities between the (1) Bromide and Viola limestones, (2) Viola and Fernvale limestones, (3) Fernvale limestone and

³ Richard V. Hollingsworth, oral communication, September, 1940.

Sylvan shale (Edson, 1930, p. 947). Strata between the Simpson group below, and the Sylvan shale above, contain the transition from the Mohawkian (Trenton) series to the Cincinnati (Richmond) series, and it is generally conceded that the Viola limestone is Trenton in age, whereas the Fernvale limestone is Richmond. Their stratigraphic contact thus represents a regional disconformity which Taff did not recognize because of the lithologic similarity of the two formations. Hollingsworth, however, has recommended the use of the term the "Viola limestone group" inasmuch as most commercial stratigraphers and field men study the two formations as a single mappable unit.⁴

In spite of all the work that has been done by those who have studied the geology of the Arbuckle Mountain region and adjacent areas, little has been published previous to this study on the detailed lithologic characteristics and stratigraphic subdivisions of the Fernvale and Viola limestones in south-central Oklahoma.

REGIONAL GEOLOGY

A study of reports on the geology of the Mid-Continent region reveals that it is necessary to consider the pre-Viola formations throughout a considerable area as potential provenances from which Viola sediments could have been derived. Furthermore, the distribution and structure of all post-Viola formations have a bearing upon the post-depositional history of the Fernvale and Viola limestones.

Regional investigations corroborate lithologic and stratigraphic evidence that the Fernvale and Viola were deposited in a widespread epeiric sea in an epoch of earth history during which no orogenic activity occurred in south-central Oklahoma. Regional stratigraphic relation of Sylvan shale, Fernvale limestone, and Viola limestone indicate, however, that a period of epeirogenic unrest was initiated throughout the area after Viola deposition, and that this unrest was the beginning of a transitional phase which led to the later development of Mississippian and Pennsylvanian basins of deposition whose axes migrated geographically from the site of the Arbuckle geosyncline.

In the determination of likely provenances for Viola sediments, the published record reveals no widespread locality where Viola beds lie on pre-Cambrian rocks; hence, it is highly improbable that Viola sediments were derived directly from basement rocks in south-central Oklahoma (Table I). With the exception of an area in southeastern Colorado, where Viola strata lie on Arbuckle limestone, no beds older than the Simpson Oil Creek formation were exposed to subaerial erosion while the Viola seas covered most of the Mid-Continent region.

The Viola limestone, thus, is almost everywhere underlain by formations of the Simpson group, which is a highly complex succession of lithographic limestone, coarsely crystalline fossiliferous limestone, waxy green shale, and fine- to coarse-grained sandstone. Hollingsworth has proved that the Bromide formation wedges out northeastward from the Arbuckle geosyncline, and that the McLish

⁴ Richard V. Hollingsworth, oral communication, January, 1947.

TABLE I

CORRELATION CHART OF ORDOVICIAN FORMATIONS OF MID-CONTINENT
(After Dott, 1941, p. 1637. Strata included in this report are outlined with heavy black line)

ORDOVICIAN

	1	2-3	4-5	6-A	6	7
	LLANO UPLIFT	WICHITAS ARBUCKLES	OUACHITAS	OZARKS (OKLAHOMA)	OZARKS (MO.-ARK.)	N. E. IOWA
S		LOWER HUNTON	BLAYLOCK SS.	ST. CLAIR	GIRARDEAU	ALEXANDRIAN
ORDOVICIAN		SYLVAN SH.	POLK CREEK	?	ORCHARD CR. THEBES	MAQUOKETA
		FERNVILLE LS.	?	FERNVILLE	FERNVILLE	
		VIOLA LS.	BIG FORK CHERT		KIMMSWICK	GALENA
		BROMIDE TULIP CREEK } MC LISH } OIL CREEK } JOINS }	WOMBLE SH. (STRINGTOWN)	FITE ? TYNER BURGEN ?	PLATTIN JOACHIM DUTCHTOWN ST. PETER EVERTON	DECORAH PLATTEVILLE FM. ?
		WEST SPRING CR. LS.			BLACK ROCK SMITHVILLE POWELL COTTER JEFFERSON CITY	
		KINDBLADE LS. COOL CREEK LS. & CHERT STRANGE DOL. MC KENZIE HILL FM MC MICHAEL LS. MEMBER CHAPMAN RANCH LS. MEM.	BLAKELY SS. MAZARN SH. ?	COTTER ?	ROUBIDOUX GASCONADE VAN BUREN	SHAKOPEE ONEOTA
	UPPER ELLENBURGER		CRYSTAL MT. SS.			
		LOWER	COLLIER SH.		EMINENCE	TREMPEALEAU
		ARBUCKLE	?	PRE-CAMBRIAN	POTOSI	
	LOWER ELLENBURGER					

* EXACT EQUIVALENTS NOT KNOWN

TABLE II

CORRELATION CHART OF PENNSYLVANIAN FORMATIONS
(Heavy lines indicate strata containing Viola débris)

PENNSYLVANIAN

	1	2	3	4	5	6	
SERIES	NORTH TEXAS	ARDMORE BASIN	CENTRAL OKLAHOMA	OUACHITA MTS. ARKANSAS VALLEY NORTH OKLAHOMA	OZARKS KANSAS NEBRASKA	MISSOURI	IOWA
	IPUEBLO GROUP	CLEAR FORK - WICHITA	STRATFORD SHALE	BELOW FORAKER LS.	ADAMSS GROUP	INDIAN CAVE SS.	?
VIRGIL		VANOSS FM.	VANOSS FM.	GRAYHORSE LSI WABANUSSE FM. BUCK CREEK FM.	BROWNVILLE LSI WABANUSSE GP.	WABANUSSE	
	CISCO SERIES		ADA FM.	PANMUSKA FM. ELGIN SS. NELAGONEY FM.	SHAWNEE GP. DOUGLAS GP. PEDEE GP. LANING GP.	SHAWNEE DOUGLAS PEDEE LANING	VIRGIL
MISSOURI	CANYON SERIES	HOXBAR FM.	OCHELATA BELLE CITY LS. FRANCIS FM. SEMINOLE SS.	OCHELATA GP. SHATOOK GP.	KANSAS CITY GP. BROWNSON GP. BOURBON GP.	KANSAS CITY	MISSOURI
DES MOINES	STRAWN SERIES	DEESE FM.	HOLDENVILLE-WETUMKA CALVIN-THURMAN BOGGY SH. WABANUSSE MC ALESTER SH. HARTSHORNE SS. ATOKA FM.	LENAPAN-FT. SCOTT CALVIN-THURMAN BOGGY SH. SAVANNA SS. MC ALESTER SH. HARTSHORNE SS. ATOKA FM.	MARMATON GP. CHEROKEE SH.	HENRIETTA CHEROKEE	DES MOINES
	LAMPASAS SERIES	BIG BRANCH FM.					
MORROW	MARBLE FALLS	L. DORNICK HILLS FM. SPRINGER FM.	WABANUSSE FM. SPRINGER FM.	JOHN VALLEY BOADLER BEARING SH. JACKFORD SS. STANLEY SH. HOT SPRINGS SS.	BLOYD HILL		
	U. BARNETT SH.						
	L. BARNETT SH.	CANEY SH.	CANEY SH.	ARKANSAS NOVACULITE	CHESTER-BOONE	CHESTER	

formation wedges out still farther northeastward.⁵ Northeastward on the Seminole platform, beyond the McLish wedge-out, Viola dolomitic strata lie unconformably on Oil Creek strata (lowest Simpson beds). It is logical, therefore, to conclude that the provenance for Viola clastic components northeast of the Arbuckle geosyncline was the Simpson group which formed the floor of the transgressing Viola seas.

The composite stratigraphic diagram (Fig. 1) indicates that the Fernvale and Viola limestones were locally uncovered and subjected to subaerial erosion after the deposition of Siluro-Devonian beds. The Wichita orogeny of early Pennsylvanian time and the Arbuckle orogeny of late Pennsylvanian time brought the entire Mid-Continent section up for erosion in some localities of south-central Oklahoma. Fernvale and Viola strata were covered and uncovered several times in post-Pennsylvanian time, and *débris* found in late Morrow and post-Morrow beds indicated that the Richmond and Trenton sections supplied sediments to later seas in areas both northeast and southwest of the Arbuckle Mountains (Table II).

The major structural features of south-central Oklahoma comprise the Semi-nole uplift, the Arkansas-Oklahoma coal basin, the Ouachita Mountains, Arbuckle Mountains, Anadarko-Ardmore basin, Wichita Mountains, Marietta syncline, and the Red River uplift. The northeast Oklahoma platform is considered to be a southwest spur of the Ozark uplift and is more a geographic designation than a dominant structural feature in south-central Oklahoma. The present geographic relation of these features is shown on the index map (Fig. 5).

DESCRIPTIVE SUBDIVISIONS

It is axiomatic in the detailed description of a formation that some subdivision of an area must be made. The necessity for using a logical areal division having some genetic significance may be taken for granted, but that division can be made only after the lithologic variations are studied. The lithologic results of this study are, therefore, presented in natural stratigraphic provinces resulting from the study itself, and the descriptions are grouped under *members*, the recognition of which resulted from the lithologic study.

Regional variations in chert, dolomite, insoluble residue, and total siliceous content prove the presence of two distinct major facies of the Viola formation in southern Oklahoma. Only one small part of the exotic Ouachita facies extends into the area of study. The remainder of the area lies over the ancient Arbuckle basin in which were deposited sediments of the Arbuckle facies. Within the Arbuckle facies lie several relatively local facies of the Viola limestone. The maps accompanying this report show reasons for the division of the area into stratigraphic provinces containing facies somewhat different from adjacent provinces, yet vertically

⁵ Richard V. Hollingsworth, oral communication, September, 1940.

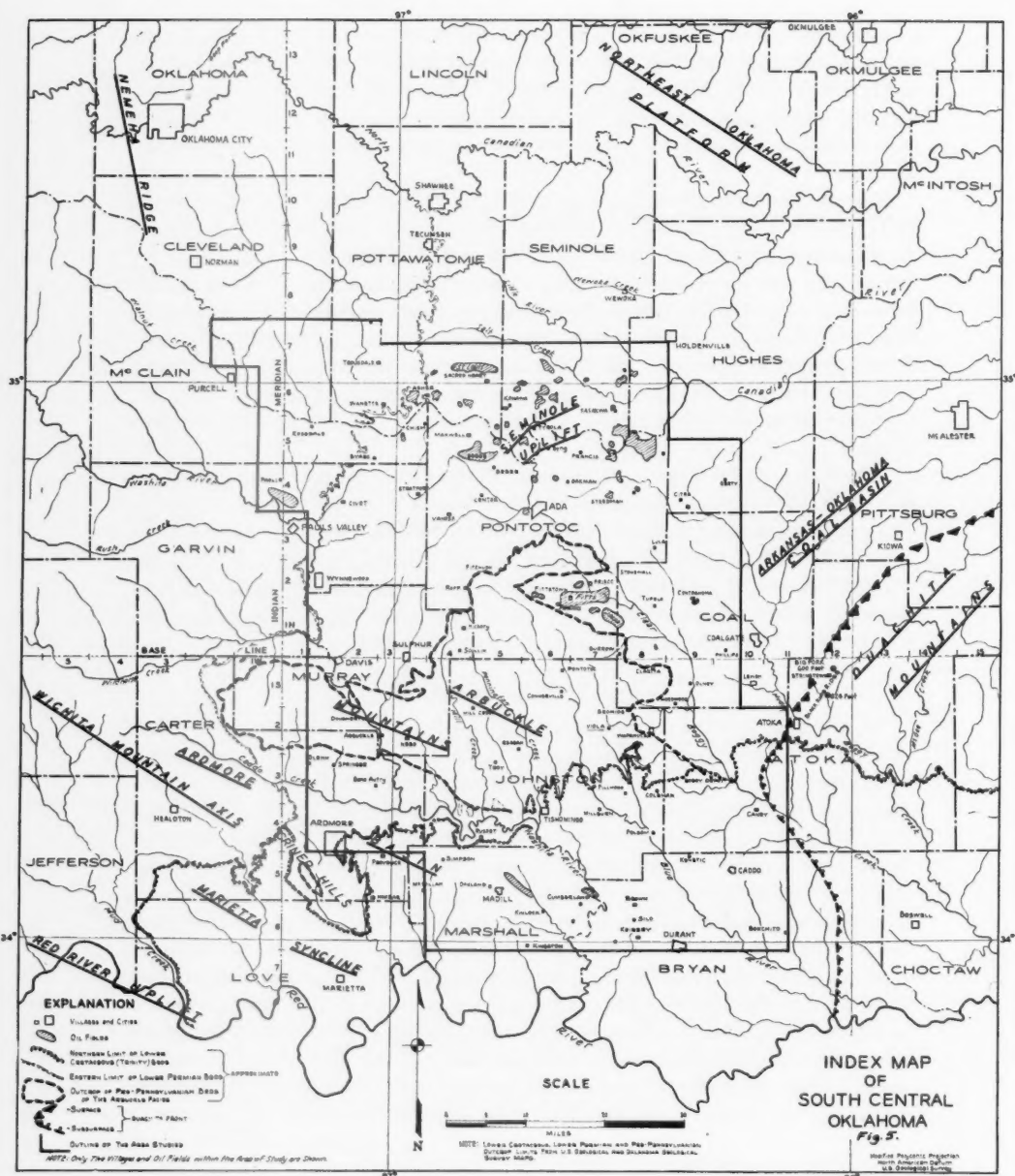


FIG. 5.—Index map of south-central Oklahoma.

divisible and horizontally correlatable throughout the whole area (Fig. 4). These provinces are named as follows for ease of reference.

Arbuckle facies	
Seminole	Platform facies
McAlester	
.....	
Fitts	Platform-slope facies
Wapanucka	
.....	
Tishomingo	Basin facies
Ardmore	
.....	
Ouachita facies	

The Viola limestone is subdivided stratigraphically into four major members which are of wide geographic extent and which otherwise fulfill the member definition proposed by the Committee of Stratigraphic Nomenclature (1933, p. 856). It is not advisable to name these members because they are essentially sub-surface platform divisions, although they are correlated with the exposures of the platform slope and basin facies. The members are, therefore, numbered from one to four, from the top to the bottom of the Viola limestone (as they are penetrated by the drill). The Fernvale limestone, overlying the Viola limestone, is not subdivided into members in this study. The Fernvale and all members of the Viola limestone are found at all the field localities studied. The subdivision of surface sections and Viola sections penetrated by wells within the Arbuckle Mountains and the Ardmore basin is difficult because of the lack of abrupt vertical lithologic changes. Surface sections were studied and sampled in the following stratigraphic provinces.

- Fitts—Murray Lane section
- Wapanucka—Robertson Creek section
- Tishomingo—Flying "L" section
- Ardmore—Highway 18 section
- Seven Sisters section
- Highway 77 section

SURFACE SECTIONS

GENERAL CONSIDERATIONS

The Fernvale and Viola limestones crop out prominently in the Arbuckle Mountains of south-central Oklahoma. Arbuckle Mountain topography is the result of differential erosion since the stripping-off of Cretaceous beds in Tertiary time. Stream erosion, combined with slope retreat caused by soil creep, gully gravure, and headward erosion of minor tributaries, has produced significant topographic forms on the Paleozoic rocks exposed in the mountains.

The location of early Paleozoic sections suitable for collection is, however, related directly to the geographic position of maximum folding in south-central Oklahoma. Pennsylvanian folding and normal faulting, as well as some thrust faulting, were best developed where the early Paleozoic rocks are the thickest, that is, in the basin facies, which were deposited in a northwest-trending basin

known as the Arbuckle geosyncline. The choice of Ordovician surface sections for collection and study was thus rather rigorously defined by paleogeographic factors related to the development of the Arbuckle geosyncline, and the later concentration of Pennsylvanian orogenic forces in the Arbuckle geosynclinal prism.

The orogenic disturbances which affected the Fernvale and Viola limestones have caused notable crustal shortening by folding and faulting which modified the form of the original Arbuckle depositional basin. Dott has suggested that overthrusting of undetermined magnitude may have occurred during the late Pennsylvanian orogeny (1934, p. 597). Tomlinson has estimated that the Ardmore basin, between the Arbuckle anticline and the Red River arch, has suffered 16 miles of crustal shortening (1929, p. 48). Though no one has published an estimate of the crustal shortening between the south limb of the Arbuckle anticline and Lawrence uplift, the schematic reconstructions by Dott showing original early Pennsylvanian folds "unscrambled" from the effects of late Pennsylvanian orogeny suggest that crustal shortening of similar magnitude occurred within the Arbuckle Mountains (Dott, 1934, Figs. 7-9, p. 594). Anomalous relations of Fernvale-Viola thicknesses in surface occurrences near subsurface sections appear to substantiate the fact that these orogenies confuse considerably a valid reconstruction of the original depositional basin as it was in Fernvale and Viola time.

Because of these factors, the facies which can be studied from surface sections are not truly representative of the formation as found in the subsurface northeast of the Arbuckle Mountains. Hence, rigorous description and correlation techniques must be applied to interrelate the members between the surface and subsurface sections, particularly along the northeast side of the Arbuckle Mountains.

AREA AND DISTRIBUTION OF OUTCROP

The Fernvale and Viola limestones are found in approximately thirty-five major outcrop areas covering about 50 square miles in the Arbuckle Mountains. Distributions of these outcrops as recorded on the map prepared by Decker and others, is shown on the base maps (Figs. 6-8). Though numerous smaller outcrops have been mapped since Decker's work, the essential structural and outcrop patterns are correct.

TOPOGRAPHIC FORM

These Ordovician formations are one of the most distinctive mappable units in south-central Oklahoma. The exposures stand out as sinuous bands which can be followed for miles on the flanks of the major anticlines in the Arbuckle Mountains. The Mississippian Sycamore limestone, Siluro-Devonian Hunton limestone, and the Ordovician Fernvale-Viola limestone underlie long ridges and high rounded hills. The valleys between the resistant ridges are eroded into the Woodford chert (Chattanooga shale) and the Sylvan shale. The width of the valleys and the ridges is controlled by the erodability, thickness, and dip of the formations.

The Fernvale formation is relatively thin, non-siliceous limestone in massive

beds easily breached by headward erosion of small tributary streams that form the frill of gulches first described by Taff (1928, p. 10). The Viola nodular cherts and non-siliceous limestone below the Fernvale limestone are irregularly bedded, and many small streams have cut short steep courses which head approximately in the middle of the outcrop. The middle member and the upper part of the lower Viola section are argillaceous and shaly with undulatory bedding. The lowest members, and, in some parts of the area the middle members, are highly siliceous with numerous layered cherts and thin claystones. Headward eroding streams seeking to breach the steeply dipping formations are diverted upon reaching the siliceous members.

The forbidding soil profile developed on the siliceous Viola hills, in contrast to excellent soils developed on the Sylvan shale above and the Bromide limestone below, serves to make delineation of the Sylvan-Fernvale and Viola-Bromide contacts on aerial photographs an accurate method of mapping the formations. The creep of Viola siliceous soils down over the Fernvale-Viola contact masks that contact, and it can be recognized readily only in the field. The height of the Viola hills is directly related to the dip of the strata and the erodability of the overlying and underlying beds; hence, it is axiomatic that in areas of lithologic similarity in the section studied, the highest hills are underlain by strata having the steepest dip.

STANDARDS OF DESCRIPTION

Qualitative and quantitative description of Fernvale and Viola strata follows in general the definitions of terms and parameters used in similar studies of other carbonate formations. Rock types are described in accordance with definitions as established by Tarr (1938, p. 10, pp. 25-27), Grim (1942, p. 226), and Twenhofel (1937, p. 91).

Sedimentary structure.—Few complex sedimentary structures are found in Fernvale and Viola rocks exposed in the Arbuckle Mountains. Cloud, Barnes, and Bridge defined various grades of bedding in the Ellenburger group of Texas as follows.

Thinly bedded: less than 3 inches thick
Medium-bedded: between 3 and 10 inches thick
Thickly bedded: more than 10 inches thick (Cloud *et al.*, 1945, pp. 134-35)

Payne described four descriptive categories of bedding.

Fissile: less than 2 mm. thick
Shaly: 2-10 mm. thick
Flaggy: 10-100 mm. thick
Massive: more than 100 mm. thick (Payne, 1942, p. 1726)

Inasmuch as the Fernvale-Viola field work was completed prior to these bedding classifications, the writer established a quantitative series as follows.

Shaly: less than $\frac{1}{2}$ inch thick
Very thin beds: $\frac{1}{2}$ -2 inches thick
Thin beds: 2-4 inches thick
Medium beds: 4-12 inches thick
Massive beds: more than 12 inches thick

Hummocky and undulatory bedding surfaces are plentiful in the upper and middle Viola limestone. Subnodular limestones separate the irregular surfaces and thin laminae of calcareous shales are plastered between the subnodular limestones. The Fernvale and lower Viola limestones, however, are characterized by planar bedding.

Viola chert shows four types of sedimentary structure.

1. Nodular
2. Subnodular
3. Irregularly nodular
4. Layered

Chert nodules are oblate and prolate spheroids, few more than 12 inches long and 6 inches thick. Nodules are quantitatively defined.

1. Small: less than 2 inches long
2. Medium: 2-6 inches long
3. Large: 6-12 inches long

Few layers of chert in the Viola limestone are more than 12 inches thick.

Lithologic description.—The color of the strata was defined by a system which DeFord designates "anarchistic; every man for himself" (1944, p. 129). Correlative color separations, based on estimates by a normal observer, were found valid for the Viola and Fernvale limestones. Until accurate and easily handled colorimeters are devised for rapid examination of cuttings under the microscope, the "anarchistic" system will no doubt prevail.

Texture has been described in quantitative terms by Wentworth, Alling, and DeFord in a manner which has advanced greatly the application of size analysis to sediments (DeFord, 1946, p. 1926). At the beginning of this study the following arbitrary textural grades were established.

Lithographic Dense (later omitted) Microgranular and crystalline	Micrograined	0.001-0.01 mm.
Finely granular and crystalline	Paurograined	0.01-0.1 mm.
Medium granular and crystalline	Mesograined	0.1-0.5 mm.
Coarsely granular and crystalline	Megagrained	0.5-5 mm.

The first column shows the size designations used, the second column shows the general quantitative terms from DeFord's excellent suggestions based on Alling's work. The term "dense," though commonly used in commercial work was dropped because of its incorrect connotations (DeFord, 1946, p. 1927) (Cloud *et al.*, 1945, p. 135). The size designations in column three deviate somewhat in the mesograined and megagrained sizes from those suggested by Alling and DeFord who use mesograined for 0.1-1.0 mm. and megagrained for 1.0-10.0 mm. in conformity with a regular logarithmic progression of the radix 10. The standard devised by the writer, based on the training by Hollingsworth in the

Shell stratigraphic laboratory, had been established and nearly 5,000 samples were studied prior to Alling's original work;⁶ hence, it was considered somewhat easier to make a logical system deviate in one parameter boundary than to re-study 5,000 samples (Fig. 3).

Standards for the description of chert are those customarily used by other stratigraphers in Mid-Continent oil fields; in this study also, description was completed before an excellent summary outline was published by another worker (Ireland, 1947, p. 1479). Color is "anarchistically" defined. Textural terminology conforms rather closely to that established by Cloud *et al.* (1945, p. 137). Three textures, recognized on the fractured surface, reflect the inherent internal characteristics of chert.

1. Chalcedonic: smooth-fracturing chert with shiny luster
2. Porcelaneous: smooth-fracturing chert with dull luster, faint suggestions of microgranularity
3. Granular: uneven fracturing chert with dull luster and obviously rough surface caused by internal granules

To these gradations, three categories of diaphaneity were added as descriptive adjectives.

1. Translucent: transmits light readily
2. Subtranslucent: transmits light poorly
3. Opaque: transmits very little or no light

FIELD LOCALITIES

MURRAY LANE SECTION

General features.—The Murray Lane locality is in the center, W. $\frac{1}{2}$, Sec. 12, T. 1 N., R. 6 E., Pontotoc County, Oklahoma (Pl. 1A). The strata on the north limb of Hunton anticline, south edge of Franks graben, dip 15°–20° NE. and strike N. 60° W. The greater part of the outcrop is found along a roadside quarry on the west side of Oklahoma Highway 99 (formerly Oklahoma Highway 48). The quarry and continuous road cut expose the greater part of the Viola limestone, whereas most of the Fernvale limestone is covered.

The thickness of Fernvale and Viola beds at Murray Lane is debatable. Decker measured the section at right angles to the strike and found it to be 472 feet thick. He mentions that the measurement was checked by plane table and states that an estimated repetition by faults requires reduction of the measured thickness to 427 feet (Decker, 1933, p. 1427). Decker's description of this outcrop, though made primarily to locate the fossil zones, is detailed enough to allow comparisons with the writer's description and measurement. There is another faulted zone above the one he describes. Both faults are high-angle reverse faults which do not cause serious repetition in the section. A thickness of 402 feet was measured in the field. Measurements between contacts shown on aerial photographs indicate a thickness of 415 feet. In view of the poorly defined Sylvan-Fernvale contact and the slight horizontal displacement caused by the faults, the aerial photo-

⁶ Alling, *Jour. Geol.*, Vol. 51 (1942), p. 266.

graphic measurements are considered a good check on the 402-foot measurement made directly on the outcrop.

From results of field and subsurface study, the Viola limestone is divided into four members, all of which are present at Murray Lane.

Sedimentary structure.—The Fernvale formation is poorly exposed in the bottom of the ditch on the west side of Oklahoma Highway 99 in Sec. 12, T. 1 N., R. 6 E. The few beds which can be studied there show it to be massive-bedded limestone. Contact with the Viola limestone is not visible, though its location can be narrowed stratigraphically to within 5 feet in the field.

The upper Viola limestone comprises beds varying from 2 to 12 inches in thickness, chert nodules from 2 to 8 inches long and 1 to 4 inches thick, with some highly irregular thin layers of chert parallel with the bedding planes of the limestone. Where the bedding planes of the limestone are undulatory or hummocky, irregular chert nodules predominate over thin irregular chert layers (Pl. 4A). Some shaly structure is notable in argillaceous limestones containing less chert near the base of the upper Viola limestone (Member one).

The middle Viola limestone is irregular, thin- to massive-bedded, with minor amounts of chert in nodules up to 6 inches long paralleling the bedding. Irregular thin dolomite layers 1-4 inches thick contain numerous small chert nodules, some of which are highly irregular in shape (Pl. 4B; Pl. 7B). Several shaly and platy argillaceous limestone beds are present near the base of the middle Viola section (Member two) (Pl. 7C).

The lower Viola limestone (Members three and four) is in beds ranging from 2 to 18 inches in thickness. Bedding is not as irregular as in the upper members, and the chert is found in long flat nodules (Pl. 7D). A few irregular nodule-like layers of chert lie near the Bromide contact, which is plainly visible. The "Lower main graptolite zone" of Decker is present at the base of the section where the limestone is parallel, though a crumbly clay layer between the Bromide and Viola limestone may represent ancient soil.

Lithologic description.—

<i>Feet</i>	
0-80	Fernvale limestone; buff, very coarsely crystalline, crinoidal limestone (Pl. 10A)
80-193	Member one. Viola limestone; light to dark buff, micro to finely crystalline, pseudo-oölitic limestone containing abundant crinoids, brachiopods, ostracods, and trilobites near base of member (Pl. 10B). White to light buff, porcelaneous, translucent to subtranslucent, calcitic chert
193-265	Member two. Viola limestone; light gray to bluish gray, micro to very coarsely crystalline, highly fossiliferous limestone (Pl. 9C). Middle of member has 22-foot section of irregularly interbedded limestone, and light brown, medium crystalline, thin dolomites. Bluish gray, chalcedonic to porcelaneous, subtranslucent to opaque, spicular, tripolitic chert present in dolomite interbeds. Member is rich in brachiopods, corals, trilobites, ostracods, crinoids, and graptolites
265-348	Member three. Viola limestone; buffish gray to bluish gray, very coarsely crystalline, highly fossiliferous limestone at top, grading downward into buff, fine to coarsely crystalline, highly fossiliferous limestone (Pl. 9D-E; Pl. 11B). Light gray to buffish gray, porcelaneous, subtranslucent, speckled, spicular chert, associated with buff limestones in lower two-thirds of member. Upper cherty lentil contains nodules of blue porcelaneous, subtranslucent, black-speckled and mottled chert

- 348-402 Member four. Viola limestone; dark grayish buff, finely crystalline, pseudo-oolitic, somewhat siliceous limestone containing many ostracods in top half of member. Light to medium buff, chalcedonic to porcelaneous, subtranslucent to opaque, highly tripolitic (?) chert. Lower 3 feet of member are dark grayish brown, micro to finely granular, argillaceous limestone with many graptolites

ROBERTSON CREEK SECTION

General features.—The Fernvale and Viola limestones were studied and measured along an unnamed creek flowing northward across Robertson Ranch in the W. $\frac{1}{2}$, NE. $\frac{1}{4}$, Sec. 19, T. 2 S., R. 8 E., Johnston County, Oklahoma (Pl. 1B). The creek is approximately $\frac{1}{2}$ mile west of Oklahoma Highway 7, $\frac{3}{4}$ mile southeast of the type locality of Viola limestone described by Taff (1902, p. 3). The outcrop is on the north limb of the Belton anticline and on the south edge of Wapanucka graben. Beds dip 60° NE. and average strike is N. 50° W. with variations from N. 40° W. to N. 60° W. The whole section, excepting a narrow zone covered by stream alluvium, is available for study along the steep sides of the valley near creek level where ephemeral high water keeps the section clear of slope débris.

The purpose of studying the Robertson Creek section was to check the 195-foot measurement reported by Decker along the highway $\frac{1}{2}$ mile southeast (1933, p. 1411). Wells drilled in the Wapanucka graben penetrated 320–430 feet of Fernvale and Viola strata, according to their location within the graben. Decker's measured section was examined and his measurement was found to be correct, but the full thickness of the section is not present along the highway because complex high-angle thrust faults throw Woodford chert against Fernvale limestone and Fernvale limestone against lower mid-Viola beds. The incomplete section was not suitable for the present study, and a complete section was found in the creek as described.

The section is 434 feet thick at Robertson Creek. Minor structural complications are numerous, and, where they can be seen, they are easily deciphered. The insoluble residues show no overlap of beds collected; therefore, the short covered distance is assumed to represent a true stratigraphic interval. The group can not logically be much thicker here than measured.

The Fernvale and four members of the Viola limestone are well exposed, though a confusing abundance of sand and lack of chert show that important facies differences probably were present in areas at the southwest, where Viola limestone is no longer present because of erosion.

Sedimentary structure.—The Fernvale limestone at Robertson Creek is massive-bedded with few minor undulations of the bedding surfaces. The beds range from 1 to 6 feet in thickness and bedding surfaces are indistinct. Twenty-four feet and 89 feet from the top of the Fernvale limestone lie 10-foot sections of thin-to medium-bedded limestones with undulatory bedding.

The upper and middle parts of the Viola limestone (Members one and two) are extremely massive, with a few highly irregular, incipient bedding surfaces.

A few small chert nodules are present in the base of upper Viola and the base of the middle Viola limestones. The paucity of chert in the Robertson Creek section is highly exceptional in comparison with all other Viola sections studied.

The lower Viola limestone (Members three and four) is predominantly thin-bedded with apparently cyclic bedding of pure limestone, siliceous limestone, layered cherts, plastic clays, and silica clays in essentially planar beds (Pl. 5A). There is no intergradation of buff silica clay (the finely divided quartz mixed with calcium carbonate) and brown plastic clays either laterally or vertically in the section.

Contact of the thin-bedded siliceous and argillaceous Viola limestone with the very massive buff Bromide limestone is easily found in the field. No angular discordance can be noted and there is no weathered clay on the contact as in the Murray Lane section.

Lithologic description.—

- Feet*
- 0-99 Fernvale limestone; pinkish to grayish buff, very coarsely crystalline and granular limestones containing abundant ostracods, brachiopods, trilobites, crinoids, and some small black gastropods (Pl. 9A). Basal 30 feet contains medium to coarse subangular to round frosted sand grains
 - 99-202 Member one. Viola limestone; upper 48 feet, light gray and light buff, fine to medium crystalline limestone with some irregular interbeds of very coarsely granular and crystalline, crinoidal limestone (Pl. 9B). This upper section also very sandy, detrital quartz grains ranging from fine to medium, subangular to subround. Many fossil fragments include parts of crinoids, brachiopods, and bryozoans. Lower 55-foot section, buff to light gray, thin, irregular, micro to finely crystalline limestone containing very few fossils. Small nodular and irregular masses near base of member are dark buff, porcelaneous, subtranslucent to translucent, spicular, speckled chert
 - 202-376 Member three. Viola limestone; upper 54 feet, buff, finely crystalline limestone containing few fossils. Lower 15 feet of 54-foot section, highly pseudo-oölitic and contains a few small nodules of light buff, porcelaneous, subtranslucent, slightly tripolitic chert. Lower 55 feet of Member three has 20 feet of buff to bluish gray, microgranular and microcrystalline limestone and nodules of light buff, porcelaneous, subtranslucent chert at top. Lowest 35 feet of Member three are thin interbeds of dark buff, microgranular and microcrystalline pseudo-oölitic limestone, brown plastic clays, brown argillaceous limestones, buff siliceous limestone, and buffish gray, chalcedonic, translucent, mottled chert. Fossils in Member three include graptolites, trilobites, crinoids, brachiopods, sponge spicules, ostracods, and bryozoans
 - 376-434 Member four. Viola limestone; interbedded planar layers of buff, microcrystalline limestone; light buff, highly siliceous limestone; dark brown, micro-layered, graptolitic, plastic clays; brown, microgranular, argillaceous limestones; light buff, porcelaneous to chalcedonic, subtranslucent to translucent chert, and light buff, trilobitic, calcareous, silica clay (Pl. 9G). Chert and even-bedded trilobitic layers showing all gradations from pure limestone to chert indicate cyclic depositional relation to graptolitic, plastic clay layers. Viola limestone is underlain here by light buff, lithographic Bromide limestone of Simpson group

FLYING "L" SECTION

General features.—Samples of the Fernvale and Viola limestone from the Flying "L" section were collected along a stream which cuts directly across the Dougherty anticline on Flying "L" Ranch in the center of S. $\frac{1}{2}$, S. $\frac{1}{2}$ NW., Sec. 27, T. 1 S., R. 2 E., Murray County, Oklahoma. The beds, as exposed on the south limb of the anticline, strike N. 45° W. and dip 70° SW. (Pl. 2A).

A diagonal vertical fault surface was noted at the top of the thin Fernvale limestone, suggesting that a small part of that member was cut out by faulting.

The Fernvale limestone, however, is absent in the Sinclair's Lancaster No. 1, 3 miles north, and is thin in much of the Arbuckle Mountain area; therefore, it may be assumed that less than 10 feet of section is missing from the top of the section in Flying "L" Creek. The Fernvale and four members of the Viola limestone are present at the Flying "L" locality.

Sedimentary structure.—The Fernvale limestone, approximately 12 feet thick, is present as beds which range from 1 to 3 feet in thickness.

Upper Viola beds (Member one) are thin to massive-bedded limestone showing blocky fracture and slightly undulatory bedding surfaces. Chert is present in nodules ranging from 2 to 6 inches in length. The basal 5 feet of this member consists of very thin irregular beds of shaly limestone.

Middle Viola strata (Member two), thin- to massive-bedded with fairly even bedding surfaces, are rich in fossils and are almost devoid of chert. The lower part of the middle Viola beds is covered with stream sands and the contact with the lower Viola limestone is not visible at this locality.

The upper 165 feet of lower Viola beds (Member three) is thin- to medium-bedded limestone with abundant undulatory shaly partings. Bedding surfaces are hummocky and resemble irregular ripple marks. Some beds attain a thickness of 12 inches between the soft shaly partings, whereas thinner beds have an irregular nodular structure. Chert nodules 3–6 inches long are found near the top and middle of this section, though total chert content is exceptionally low compared with correlative Viola beds in other localities. The lower 212 feet of Viola limestone (Member four) is planar-layered medium- to massive-bedded limestone interbedded with 2–6-inch nodules and thin layers of chert. Thin, highly siliceous limestone and calcareous plastic clay layers are present as interbeds throughout the bottom part of the section. Sharp parallel contact with light greenish gray lithographic Bromide limestone is easily recognized in the creek bed at this locality.

Lithologic description.—

<i>Feet</i>	
0–12	Fernvale limestone; dark buff, coarsely crystalline, highly fossiliferous limestone
12–142	Member one. Viola limestone; dark buff, micro- to medium-crystalline limestone containing scattered fragments of trilobites, crinoids, brachiopods, and an abundance of ostracods. Grayish buff, chalcedonic to porcelaneous, highly translucent to subtranslucent, tripolitic, spicular chert throughout member
142–230(?)	Member two. Viola limestone; dark grayish buff, microcrystalline to microgranular, glauconitic, pseudo-oölitic, limestone with coarsely granular, macerated fossil layers near middle of member. This highly fossiliferous member contains crinoids, brachiopods, trilobites, graptolites, and ostracods. No chert
230(?)–395	Member three. Viola limestone; gray to bluish gray, micro- to fine-crystalline limestone with several lentils of medium granular, fossiliferous limestone. Shell fragments include trilobites, ostracods, graptolites, brachiopods, and very small gastropods. Nodular chert is dark buffish gray, chalcedonic to porcelaneous, translucent, and mottled
395–607	Member four. Viola limestone; dark buff, microcrystalline, slightly siliceous limestone at top (37 feet) containing nodules of gray, porcelaneous, translucent chert and some dark buff, microgranular, subtranslucent chert. Light to dark gray, highly siliceous, microcrystalline limestone interbedded with bluish gray, microgranular, argillaceous limestone and thin layers of chert. Lower 25-foot section, reddish brown, microgranular, highly siliceous limestone

HIGHWAY 18 SECTION

General features.—Fernvale and Viola samples were collected in a small creek valley and road cut along Highway 18 in the center of SW. $\frac{1}{4}$, Sec. 12, T. 3 S., R. 3 E., Carter County, Oklahoma. Here the Viola limestone strikes N. 70° W. and dips 60° SW. The beds are exposed in a creek wall and along the road cut following the small stream that flows southward (Pl. 2B).

The upper contact is easily recognized in the field and on the photographs, but the Bromide-Viola contact must initially be identified in the field. Vegetation does not delineate the contact here, but once it is established in the field it can be followed in photographs by noting the darker shade of the soils developed on Bromide limestone, in contrast to the light siliceous soils of the Viola limestone.

The field measurements of 615 feet for the total thickness of the section at this locality is believed to be correct. Decker measured a 686-foot section at the West Branch of Sycamore Creek $5\frac{1}{2}$ miles southeast. No structural complications were noted in the field or on the aerial photographs and the Fernvale and all four members of the Viola limestone are exposed here.

Sedimentary structure.—The Fernvale limestone is medium- to thick-bedded; the middle part is composed of slabby, irregular beds.

The upper part of the Viola limestone (Member one) contains thin, medium and thick beds ranging from 2 to 18 inches in thickness. The massive beds are bounded by even bedding surfaces whereas the thin beds are undulatory and knobby or irregular. Abundant chert is present in large flat nodules ranging from 4 to 8 inches in diameter.

The middle Viola limestone (Member two) comprises very massive beds of fossiliferous limestone, ranging to 3 feet between even bedding surfaces, interbedded with shaly limestone and calcareous shales plastered on undulatory bedding surfaces. A part of the section consists of platy, highly irregular, subnodular limestones. Chert is present in thin, flattened nodules and knobby layers parallel with the bedding surfaces.

The upper 50 feet of lower Viola limestone is slabby and irregularly bedded, with nodular cherts near the top. The remainder of the lower Viola limestone is thinly bedded with planar bedding surfaces. Shaly structure is predominant in the argillaceous limestone, and the cherts are in thin (1–3 inches) layers and thin long nodules.

Contact with the light greenish gray lithographic Bromide limestone is sharp and parallel with Bromide bedding.

Lithologic description.—*Feet*

- 0–19 Fernvale limestone; buff to gray medium to coarsely crystalline and granular highly fossiliferous limestone containing fragments of trilobites, brachiopods, and crinoids
- 19–148 Member one. Viola limestone; buff and gray, finely crystalline limestone with a few interbeds of medium to coarsely crystalline, fossiliferous limestone near base. Abundant ostracods, crinoids, trilobites, brachiopods, and bryozoans. Buff to grayish buff, chalcedonic to porcelaneous, translucent, spicular, slightly tripolitic chert

- 148-244 Member two. Viola limestone; reddish to buffish gray, coarsely granular and crystalline limestone interbedded with microgranular and finely crystalline limestone. Coarse-grained limestones contain abundant crinoids, brachiopods, and trilobites. Middle part of the member contains moderate amounts of grayish buff, waxy, chalcedonic, translucent, spicular chert
- 244-447 Member three. Viola limestone; upper 50 feet, dark grayish buff, microcrystalline limestone containing coarse granules composed of trilobite fragments, crinoid columnals, brachiopods, and ostracods. Some buff porcelaneous, translucent chert nodules near top of member. Lower 253 feet, interbedded, bluish gray, micrograined, fossiliferous, argillaceous limestone, buffish gray, graptolitic, calcareous shales, greenish buff and gray calcareous silica clay layers, and dark gray, microcrystalline, siliceous limestone. Fossils in lower part of member, trilobites, graptolites, brachiopods, and ostracods. Graptolites in argillaceous lentils, whereas trilobites occur in silica clay and siliceous limestones. Only a trace of chert near middle of member
- 447-615 Member four. Viola limestone; steel gray to buffish gray, highly siliceous limestone interbedded with greenish buff, microgranular, calcareous silica clay, dove-gray, microcrystalline limestone, brownish gray and brown, calcareous plastic clay layers. Thin layers in 30-foot section near middle of member are buffish and reddish gray waxy, chalcedonic translucent chert. Traces of trilobites and graptolites in siliceous and argillaceous layers,

SEVEN SISTERS SECTION

General features.—Fernvale and Viola strata are exposed in excellent road cuts along a county highway over the Seven Sisters hills in Secs. 29 and 30, T. 1 S., R. 2 E., Murray County, Oklahoma. The Seven Sisters are high round knobs cut on strata which crop out on the faulted, overturned, north limb of the Arbuckle anticline (Pl. 6A). The northwest end of the outcrop is cut by major and minor faults not shown on Decker's map. The Washita syncline, a sharp overturned structure, the axis of which lies directly beneath, or somewhere southwest of, the Seven Sisters locality, separates the north limb of the Arbuckle anticline from the Dougherty anticline on the northeast, where samples were collected from the Flying "L" section.

The winding Seven Sisters road provides three fresh road cuts at right angles to the strike, which is N. 50° W. Beds are overturned toward the northeast, and the dip varies from 55° to 75° SW. (Pl. 3A).

The section is 682 feet thick at this locality and contacts are visible. The Sylvan-Fernvale contact is directly visible in few places in the Arbuckle Mountains, but here the Fernvale limestone can be seen lying on top of the Sylvan shale in the SE. $\frac{1}{4}$, NE. $\frac{1}{4}$, Sec. 30.

The Fernvale and all four members of the Viola limestone are here exposed.

Sedimentary structure.—The Fernvale limestone is thin- to medium-bedded at this locality. Bedding surfaces are regular and parallel with those below the Fernvale-Viola contact.

The upper Viola limestone is thin- to medium-bedded with highly irregular and hummocky bedding surfaces. Chert nodules are 3-6 inches in length and in some beds are 2-4 inches thick.

The middle Viola limestone is medium- to massive-bedded and contains abundant irregular chert nodules up to 8 inches long in the upper 75 feet, whereas the lower part contains no chert and has a predominantly shaly structure with irregular bedding and a few very massive highly fossiliferous layers (Pl. 6B).

The lower Viola limestone varies greatly in the massiveness of its beds. Three-

to 5-foot beds characterize the uppermost part; fine to medium beds are present in the upper part of the lower Viola; shaly structure and very thin non-shaly beds characterize the middle of the lower Viola; and the lower part is planar-bedded thin layers of chert, silica clay, plastic clay, and siliceous limestone. The cherts of the lower Viola limestone are nodular near the middle of the lower Viola, and form distinct layers (non-nodular) in the lower 150 feet of the section. Contact with the buffish gray, lithographic, bryozoan Bromide limestone is distinct and there are no local angular discordances between Bromide and Viola strata (Pl. 7E-H).

Lithologic description.—

Feet

- 0-26 Fernvale limestone; buffish gray, medium to very coarsely granular and crystalline limestone containing abundant crinoids, brachiopods, and ostracods
- 26-139 Member one. Viola limestone; buff and buffish gray, micro to finely crystalline and microgranular limestone with a few coarsely granular fossil fragmental layers near base of member. Fossils include abundant ostracods, trilobites, crinoids, traces of graptolites, and brachiopods. Nodular cherts are predominantly light buff, chalcedonic, and highly translucent, with some grayish buff, waxy, chalcedonic to porcelaneous, translucent to subtranslucent nodules
- 139-246 Member two. Viola limestone; upper 75 feet, buffish gray, microcrystalline to finely crystalline limestone containing gray, chalcedonic, translucent chert and buff, microgranular, opaque chert. Lower 32-foot section, dark gray, micro- to medium-crystalline limestone and bluish gray, microgranular to medium granular, argillaceous, glauconitic limestone (Pl. 11A). These lower beds contain abundant graptolites, very large crinoids, small crinoids, ostracods, brachiopods, and a few discoid fish scales
- 246-448 Member three. Viola limestone; brownish and greenish gray, micro to finely crystalline, glauconitic, highly fossiliferous limestone in upper 60 feet. Large crinoids, ostracods, graptolites, and trilobites. Cherts are light gray to bluish gray, porcelaneous, and subtranslucent (Pl. 11C). Lower 142-foot section, gray to brownish gray, microcrystalline limestone with few fossils and trace of light gray, porcelaneous, subtranslucent chert
- 448-682 Member four. Viola limestone; upper 100-foot section, dove gray, highly siliceous limestone interbedded with yellowish green and greenish gray, microgranular, calcareous silica clay. Chert in dove-gray limestone is greenish buff, porcelaneous, subtranslucent, and grades, within finite layers, into calcareous silica clay. No chert in lower part of upper section where calcareous silica clay is predominant over limestone. Lowermost 134 feet, gray, microcrystalline, siliceous limestone interbedded with dark gray, chalcedonic, translucent chert, dark red and brown, waxy, chalcedonic, highly translucent chert, and brown to black, bituminous, graptolitic, microgranular limestone and plastic clay layers (Pl. 9H; Pl. 12). Member four contains some brachiopods and ostracods, abundant graptolites in calcareous plastic clay layers, and abundant trilobites in silica clay and siliceous limestone beds

HIGHWAY 77 SECTION

General features.—Fernvale and Viola strata crop out along U. S. Highway 77 in the center of S. $\frac{1}{2}$, NE. $\frac{1}{4}$, Sec. 25, T. 2 S., R. 1 E., Carter County, Oklahoma. This section is on the south limb of Arbuckle anticline. The beds underlie high rounded barren hills which have a frill of gulches caused by streams eroding headward toward the middle of the formation from either side. Tulip Creek has breached the outcrop completely and the highway follows its canyon (Pl. 3B).

The thickness of the Fernvale-Viola section measured along Highway 77 is 723 feet. There are no structural complications visible either in the field or on the aerial photographs. Decker records the thickness of section along Highway 77 as 836 feet. The measurement was published in 1933, 8 years before aerial photographs of the area were available (Decker, 1933, p. 142). Decker's lithologic de-

scriptions and notations about location in the outcrop in relation of test pits and the quarry reveal that a large error was made in measurement across the field exposure. It was realized that the difference between his measurements and the writer's was great; therefore triple check was made of the thickness by pacing, by two horizontal measurements chained at right angles to the strike, and by measurements on a controlled aerial photographic mosaic. None of these showed a discrepancy of more than 20 feet in comparison with the direct measurement of 723 feet. It may, therefore, be assumed that Decker's measurement contains some accidental errors.

The Fernvale and the four members of the Viola limestone are here exposed.

Sedimentary structure.—The Fernvale limestone is thin- to massive-bedded at Highway 77 locality. Bedding surfaces are regular.

The upper Viola limestone comprises regular, very massive beds (1–3 feet) and slabby, knobby, irregular, thin to medium beds. Chert is present in thick nodules, 4–8 inches long.

The middle Viola limestone (Member two) is slabby, subnodular, and irregularly bedded, with layers ranging from 2 to 12 inches in thickness. A few massive beds (more than 12 inches thick) showing regular bedding are present. Only a few small, thick, nodules of chert occur in the middle Viola limestone.

The lower Viola limestone shows shaly, slabby, and medium, irregularly bedded layers, with abundant shaly partings in the upper 160-foot section. The next 40-foot non-cherty section is even-bedded with limestone layers ranging from 6 to 12 inches in thickness separated by 1–2-inch shaly limestone partings.

The lowermost Viola limestone (Member four) is medium- to massive even-bedded and highly siliceous. Some regular shale partings are present and the cherts are in 1–3-inch beds. Nodular cherts are rare, but where present, are intrastatally distributed and grade outward into highly siliceous limestones (Pl. 8). The lowest 120-foot section is extremely cherty and highly siliceous limestone which contrasts greatly with the very massive almost pure lithographic Bromide limestone below.

Lithologic description.—

Feet

- 0–21 Fernvale limestone; grayish buff, medium to coarsely crystalline and granular, highly fossiliferous limestone. Large crinoid columnals and trilobites constitute more than a fourth of the rock
- 21–137 Member one. Viola limestone; gray, microcrystalline to medium-crystalline, hard limestone containing trilobites and ostracods. Buffish gray to gray, chalcedonic, highly translucent chert with buff porcelaneous, subtranslucent, tripolitic chert. Traces of light bluish gray, chalcedonic, highly translucent chert
- 137–262 Member two. Viola limestone; dark reddish, brownish, and bluish gray, micro- to fine-crystalline and granular limestone, highly argillaceous at top, and very coarsely crystalline and granular near base. Member contains abundant trilobites, brachiopods, graptolites, and crinoids in top 12-foot argillaceous section, and abundant ostracods, brachiopods, crinoids, and trilobites in lower 30-foot section. Milky grayish, chalcedonic highly translucent chert and dark waxy buffish gray, chalcedonic, translucent chert in upper 20 feet. Traces of light brown, mottled, porcelaneous, translucent chert near middle and near base of member

- 262-497 Member three. Viola limestone; upper 123 feet, buffish gray to dark steel gray, micro to finely crystalline, hard limestone containing trace of light buff porcelaneous, translucent chert near top and abundant dark gray to waxy brownish gray, chalcedonic, translucent, speckled, spicular chert in lower 35 feet. Lower 112-foot section, dark steel gray, microcrystalline, trilobitic limestone near top, grading downward into greenish brown, medium to coarsely granular, highly argillaceous limestone, greenish gray, microgranular, siliceous limestone, and dark gray, micro to finely crystalline, highly siliceous limestone. No chert in this lower 112-foot section. Fossils include abundant, very coarse, trilobite fragments, a few small gastropods, fish scales, and ostracods, brachiopods, and numerous graptolites.
- 497-723 Member four. Viola limestone; dark steel gray, microcrystalline, highly siliceous limestone interbedded with buff, microgranular, limy, silica clay layers; brown, microgranular, argillaceous limestone layers; dove-gray, micro to finely crystalline limestone; and dark reddish gray to black, microcrystalline, highly siliceous, bituminous limestone at base of formation. Member four contains layers of dark bluish gray, porcelaneous, translucent chert near top, and very dark gray, brownish gray, and black porcelaneous, subtranslucent to opaque, chert throughout lower half.

SUBSURFACE SECTIONS

GEOGRAPHIC AND GEOLOGIC DISTRIBUTION

Base maps utilized for the entry of lithologic, stratigraphic, and structural data assembled for the present study show the distribution of the tests from which cuttings were studied. Most of the tests were drilled in Pontotoc, Coal, and Atoka counties; however, samples from a few tests in Murray and Johnston counties were studied.

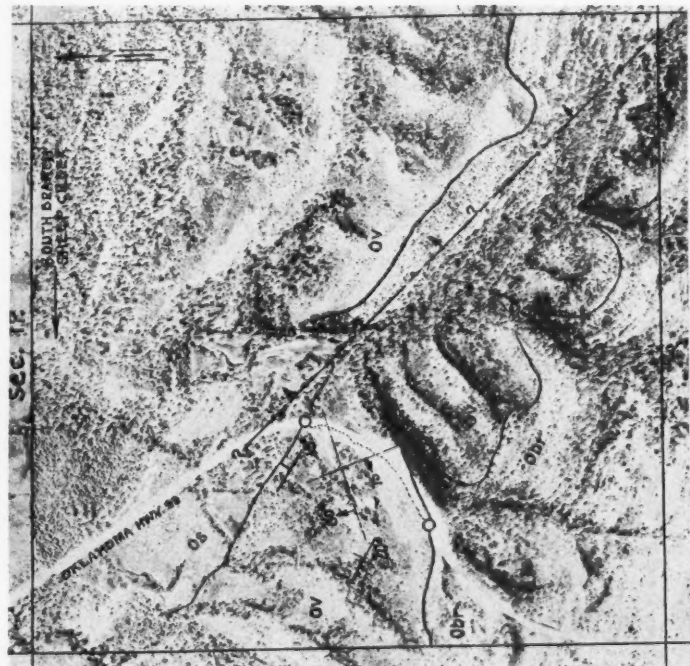
Most of the drill holes are located on the Seminole uplift, on the northward extension of the ancient Hunton arch, on the Lawrence uplift, in the Franks graben, in the McAlester basin, and in the Wapanucka graben. Some samples were deliberately chosen from areas such as the Pauls Valley anticline, where a part of the Fernvale and Viola limestones had been removed by early and late Pennsylvanian erosion and the erosion surface covered by Pennsylvanian sediments.

SAMPLING TECHNIQUE

Cable-tool wells, and rotary wells in which formations above the Fernvale limestone were cased off before drilling the Fernvale, provided the cleanest cuttings for quantitative study. Sixty-seven rotary tests yielded samples too contaminated for quantitative residue preparation, but by using the relatively uncontaminated cable-tool and rotary-tool cuttings as key wells and by making careful sample descriptions, it was possible to use the lithologic data from these 67 tests for subdivision and correlation of the Fernvale and Viola limestones.

The first control on choice of cuttings for study was, of course, their availability. A second control was the distance between tests. Hundreds of wells have been drilled in the area of study and examination of all was obviously impractical. Tests were chosen at least two or more miles apart, but some undrilled areas precluded direct study.

Table III shows the list of tests from which cuttings were studied. Every effort was made to reconstruct the drilling history of each suite of cuttings in order that sampling errors and contamination could be adequately appraised.



MURRAY LANE LOCALITY

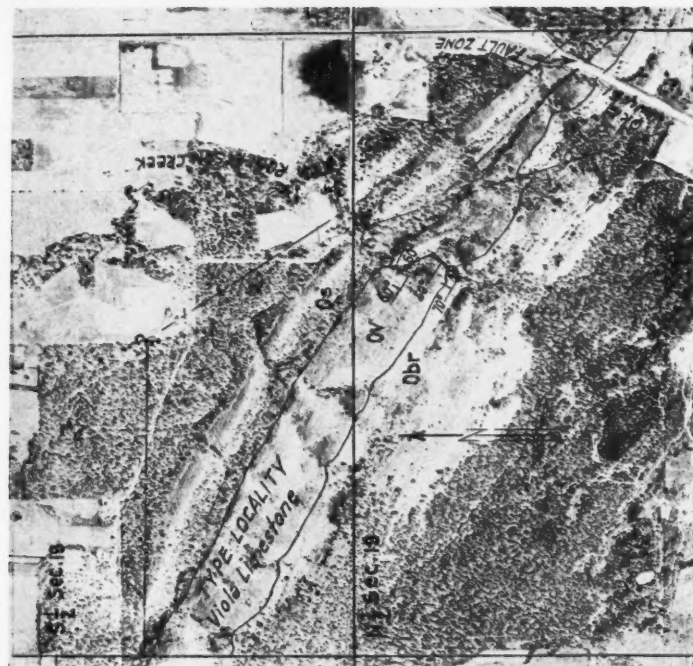
Section 12, T-1-N-R-6-E

Average Scale
0 1000 2000
Feet

- Os - Sylvan Shale
- Ov - Viola Limestone
- Obr - Bromide Formation
- Viola Contacts
- Faults
- Dip and Strike
- Measured Section

PLATE 1

A. Vertical aerial photograph of Murray Lane locality, north limb of Hunton anticline, Arbuckle Mountains, Pontotoc County, Oklahoma.



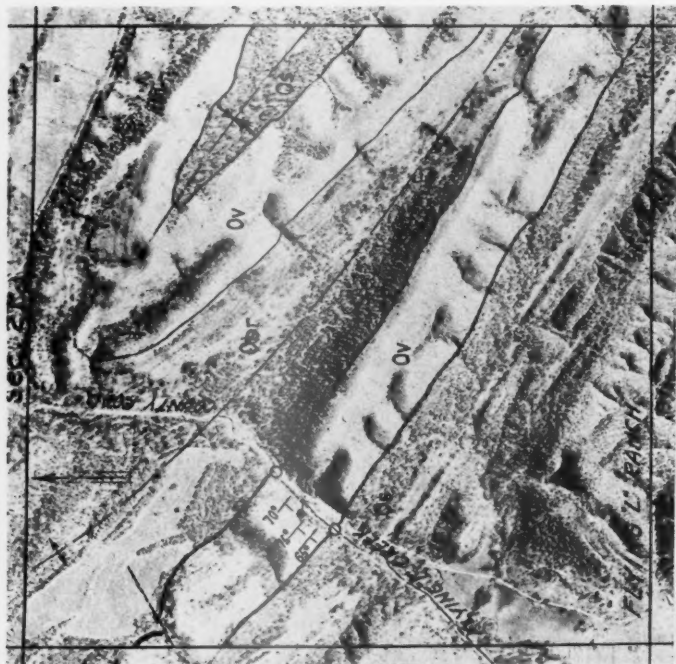
ROBERTSON CREEK LOCALITY

Sections 18 & 19, T-2-S-R-6-E

Average Scale
0 1000 2000
Feet

- Os - Sylvan Shale
- Ov - Viola Limestone
- Obr - Bromide Formation
- Viola Contacts
- Faults
- Dip and Strike
- Measured Section

B. Vertical aerial photograph of Robertson Creek locality, north limb of Belton anticline, Arbuckle Mountains, Johnston County, Oklahoma.



FLYING "L" LOCALITY

Section 27, T-1-S-R-2-E

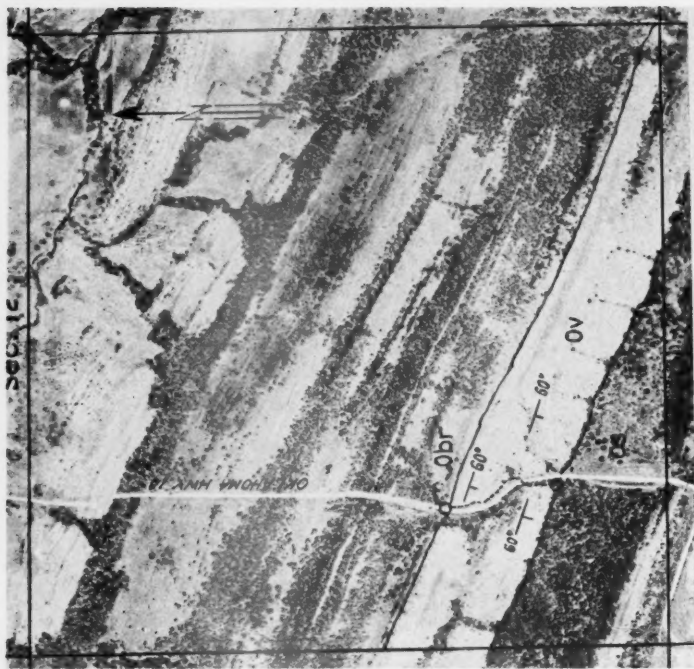
Average Scale



- Os-Sylvan Shale
- Ov-Viola Limestone
- Obr-Bromide Formation
- Viola Contacts
- Faults
- Structural Axes
- Dip and Strike
- Measured Section

PLATE 2

A. Vertical aerial photograph of Flying "L" locality, south limb of Dougherty anticline, Arbuckle Mountains, Murray County, Oklahoma.



HIGHWAY 18 LOCALITY

Sec. 12, T-3-S-R-3-E

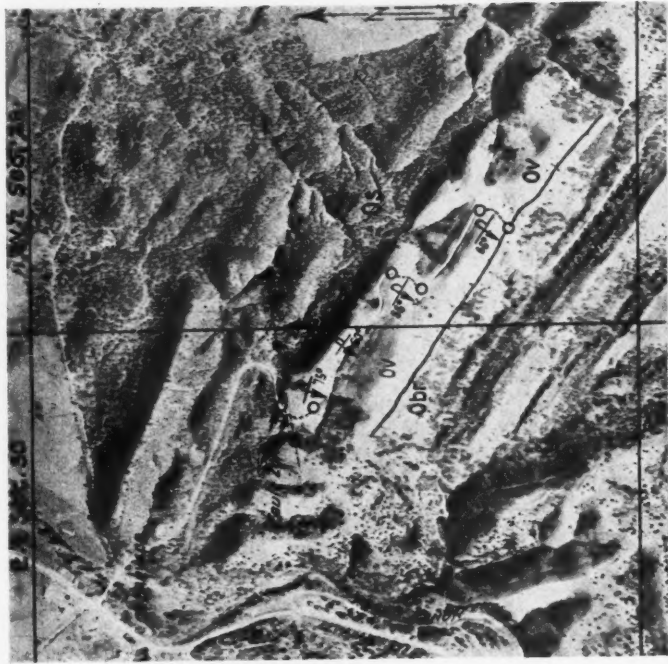
Average Scale



- Os-Sylvan Shale
- Ov-Viola Limestone
- Obr-Bromide Formation
- Viola Contacts
- Dip and Strike
- Measured Section

B. Vertical aerial photograph of Highway 18 locality, south limb of Arbuckle anticline, Arbuckle Mountains, Carter County, Oklahoma.

A. Vertical aerial photograph of Flying "L" locality, south limb of Dougherty anticline, Arbuckle Mountains, Murray County, Oklahoma.



SEVEN SISTERS LOCALITY Sections 29 & 30, T1S - R2E

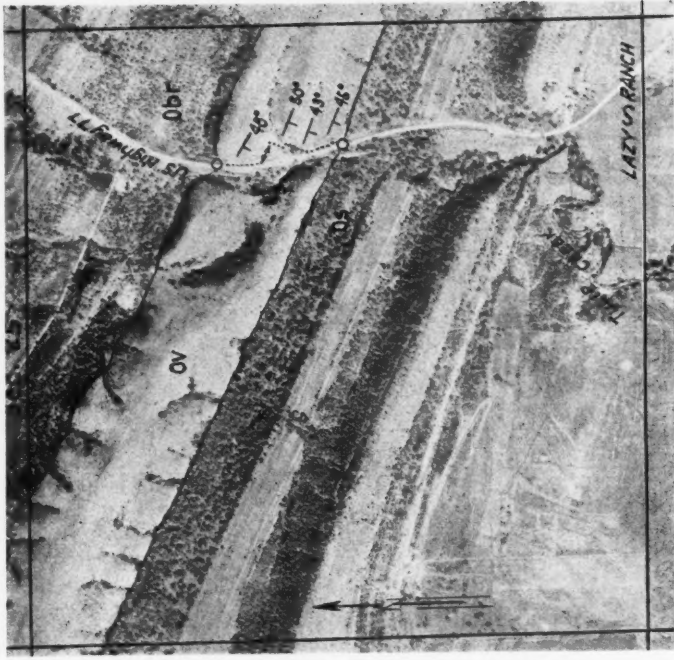
Average Scale
0 100 1200
Feet

- Os - Sylvan Shale
- Ov - Viola Limestone
- Obr - Bromide Formation
- Viola Contacts
- Faults
- Dip and Strike

PLATE 3

A. Vertical aerial photograph of Seven Sisters locality, north limb of Arbuckle anticline, Arbuckle Mountains, Murray County, Oklahoma.

anticline, Arbuckle Mountains, Carter County, Oklahoma.



HIGHWAY 77 LOCALITY Sec. 25, T2S - R1E

Average Scale
0 1000 1500
Feet

- Os - Sylvan Shale
- Ov - Viola Limestone
- Obr - Bromide Formation
- Viola Contacts
- Dip and Strike
- Measured Section

B. Vertical aerial photograph of Highway 77 locality, south limb of Arbuckle anticline, Arbuckle Mountains, Carter County, Oklahoma.



PLATE 4

A. Subnodular, irregularly bedded, upper Viola limestone and interstratal chert. Member 1. Strike N. 40° W., dip 26° NE. Murray Lane locality, Center, SE., NW., Sec. 12, T. 1 N., R. 6 E., east side of Oklahoma Highway 99.

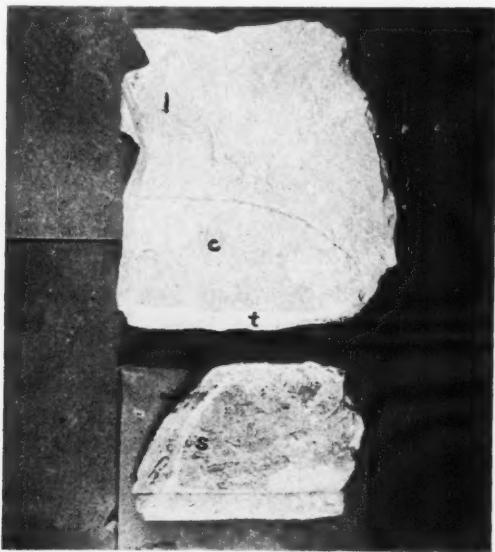


B. Bluish gray, porcelainous, subtranslucent to opaque, spicular chert nodule. Murray Lane locality, Member 2, west side of Oklahoma Highway 99. Translucent scale, 6 inches long.



PLATE 5

A. Even-bedded Viola limestone with thin subnodular interstratal layers of chert (point of hammer) and shaly interbeds (lower left). Strike N. 52° W., dip 50° NE. Member 3. Robertson Creek locality, Center, NW., NE., Sec. 19, T. 2 S., R. 8 E. View northward.



B. *Upper*: Siliceous limestone (i) containing 20% silica clay and nodule of calcareous semi-chert (c) comprising more than 50% silica clay and impurities. Note layer of tripoli (t) developed on present erosion surface. Chert-like nodular form occurs in layers with high silica clay content, yet both nodule and enclosing siliceous limestone have unmistakable microcrystalline texture, typical of lower Viola limestone.

Lower: Weather-etching of concentric shells of silica clay (s) tripolitized on present erosion surface. Siliceous limestone shows no similar etched lines on weathered surfaces. Member 4, Robertson Creek locality, Center, NW., NE., Sec. 19, T. 2 S., R. 8 E. (Small white square is 2 millimeters on a side.)



PLATE 6

A. Seven Sisters locality, NW., NW., SW., Sec. 20, T. 1 S., R. 2 E. View southeastward across Washita syncline to Tishomingo anticline in extreme distance. Viola limestone, overturned to north (left), is characterized by steep grass-covered hills breached by intermittent streams heading in shaly strata of Members 2 and 3. Sylvan shale contact (left foreground) is easily defined on aerial photographs through aid of bushes and low trees.



B. Irregular chert masses and nodules on hummocky or undulatory bedding typical of upper and middle Viola limestone. Member 2. Seven Sisters locality, SE., SE., NE., Sec. 30, T. 1 S., R. 2 E.

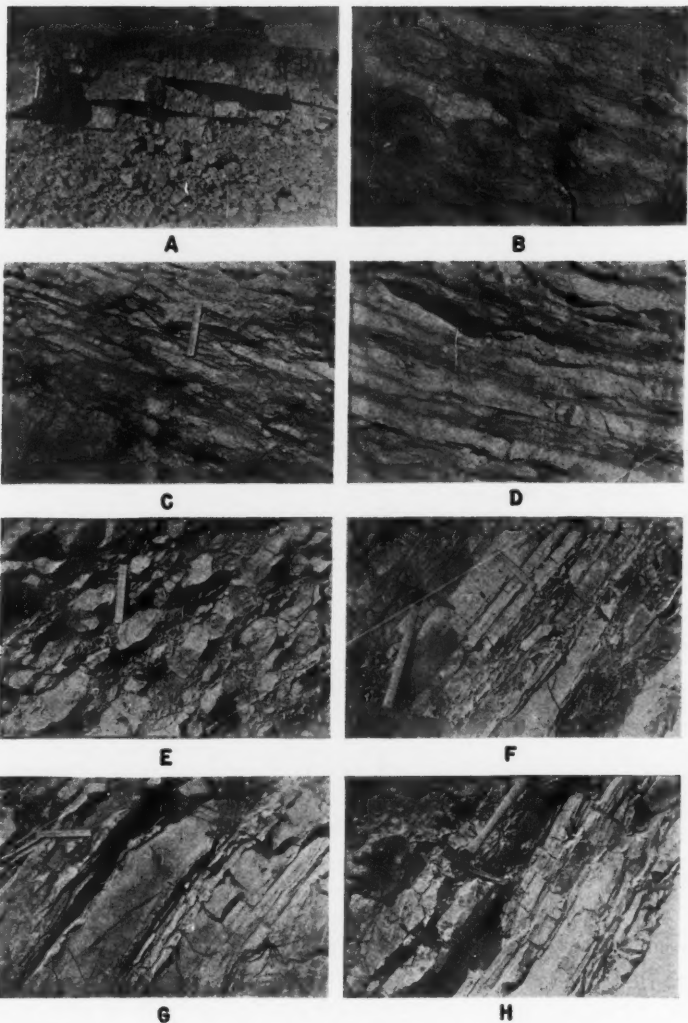


PLATE 7. Outcrop Photographs.

A. Massive, coarsely crystalline, Fernvale limestone. Lawrence quarry, NW., Sec. 36, T. 3 N., R. 5 E.

Murray Lane Locality, S. $\frac{1}{2}$ SE., NW., Sec. 12, T. 1 N., R. 6 E.

B. Dark gray chert nodules surrounded by brown argillaceous dolomite interbedded with gray, finely crystalline, fossiliferous limestone. *Member 2*, Murray Lane locality.

C. Shaly argillaceous limestone above prominent limonitized pyrite layer near base of *Member 2*. Correlative with shaly beds near base of *Member 2* at Seven Sisters locality.

D. Sub-spherical and oblate-spheroidal chert nodules and thin beds of calcareous silica clay on bedding surfaces and within limestone lentils near base of Viola limestone. *Member 4*. Note similarity of these lower limestones with even-bedded lower Viola limestones in other localities where cherts are layered.

Seven Sisters Locality, Sec. 29, T. 1 S., R. 2 E.

E. Shaly structure of calcareous mixed plastic and silica clays separating siliceous subnodular limestone. Near base of *Member 3*.

F. Even-bedded, calcareous, silica clay and siliceous limestone. *Member 4*.

G. Layers of silica clay which grade through semi-chert to chert. Note evidence of cyclic sedimentation of regularly bedded silica clay and calcareous sediments. *Member 4*.

H. Close-up of Bromide-Viola contact. Siliceous Viola limestone, on right; lithographic Bromide limestone with abundant bryozoans on left. Note 2-inch layer of brown, calcareous, plastic clay on contact.

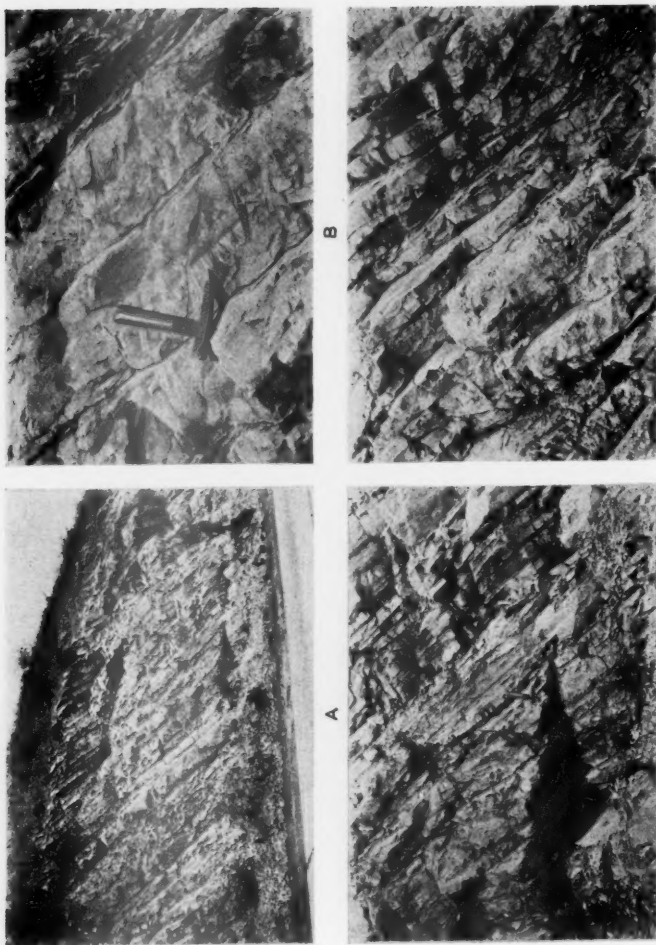


PLATE 8. Outcrop Photographs.

Highway 77 Locality, S. 4, NE., Sec. 25, T. 2 S., R. 1 E.

A. Even-bedded, siliceous, Viola limestone and layered chert, with some massive and shaly beds. Top part of Member 4; east side of highway. Strike N. 60° W., dip 48° SW. View southeastward.

B. Subnodular, layered Viola chert grading vertically and laterally into siliceous limestone. Member 4. Note intrastratal position of chert in contrast to concentration of chert nodules along bedding surfaces in upper Viola limestone. Shaly bed in upper part of chert.

C. Siliceous limestone with shaly structure, interbedded with layered cherts. Member 4. These limestones may grade from shaly calcareous silica clay to chert or from siliceous limestone to chert.

D. Interbedded, layered chert and siliceous limestone. Member 4. Thin beds of plastic clay intercalate siliceous limestone, but shaly siliceous limestones and calcareous silica clays contain almost no plastic clay.

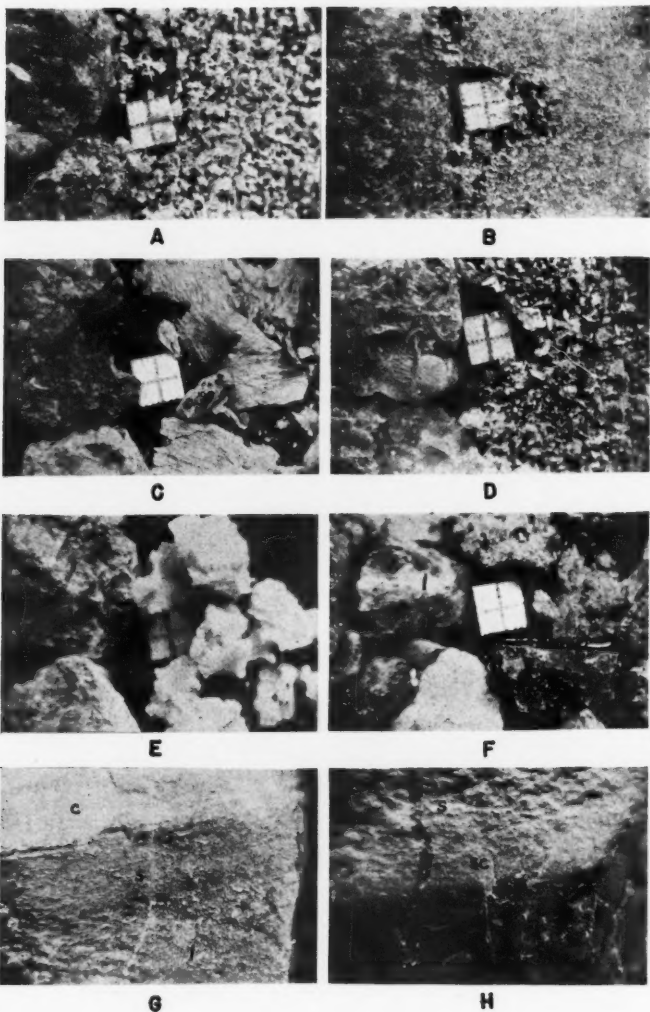
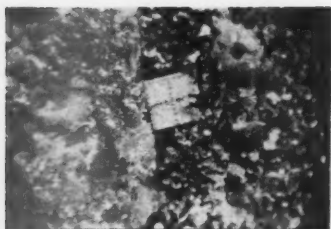
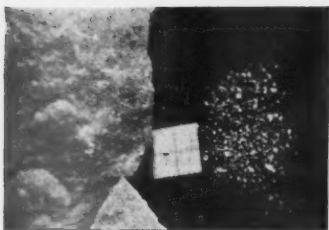
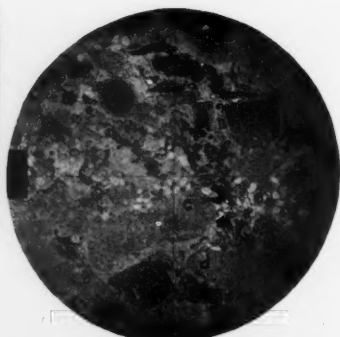


PLATE 9. *Lithology and Insoluble Residues of Fernvale and Viola Limestones.*

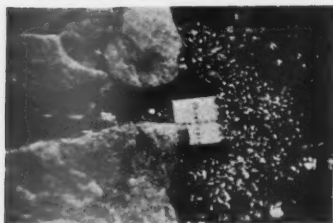
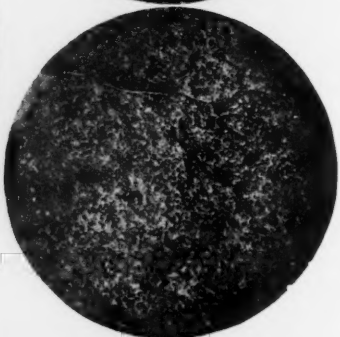
- A. *Left:* Buff, coarsely crystalline, Fernvale limestone.
Right: Digest is filigree, interstitial, microcrystalline silica, less than 1% of sample. Fernvale. Robertson Creek locality. (Small scale of 4 sq. mm.)
- B. *Left:* Light buff, coarsely granular, sandy limestone.
Right: Medium, subangular to subround, frosted, quartz sand comprises 23% of sample. *Member 1*. Robertson Creek locality.
- C. *Left:* Light gray, microcrystalline limestone with scattered coarse fragments of fossils.
Right: Insoluble residue of white, microcrystalline, siliceous brachiopod shells. *Member 2*. Murray Lane locality.
- D. *Left:* Bluish gray, very coarsely crystalline, highly fossiliferous limestone (bryozoans, brachiopods, trilobites, ostracods).
Right: Insoluble residue 10%. White, flaky, shelly, and filigree, microcrystalline silica replacing fossil fragments and filling inter- and intra-fossil spaces. *Member 3*. Murray Lane locality.
- E. *Left:* Buffish gray, coarsely granular and crystalline limestone with abundant bryozoans and trilobite fragments.
Right: White, coarse grains of interstitial, microcrystalline silica which molds original detrital fragments of fossils. Note that fossil fragments were not silicified. Top of *Member 3*. Murray Lane.
- F. *Left:* Light gray, coarsely granular, speckled, fossiliferous limestone (l).
Right: Dark gray, speckled, porcelaneous, translucent, calcimoldal chert (c) and light gray, massive, shelly, and spongy silica (s). Residue is 10% of sample, 4,385-4,390 feet, *Member 4*. Skelly Akers No. 1. Sec. 36, T. 2 N., R. 6 E.
- G. Gradation from buff, microcrystalline to finely granular, siliceous limestone (l) to microgranular semi-chert (s) to porcelaneous, translucent chert (c). *Member 4*. Robertson Creek locality.
- H. Buffish gray, chaledonic, translucent chert (c) grading upward into light buff, microgranular, opaque silica clay (s) through non-calcitic semi-chert phase (sc). Note unweathered calcite vein. *Member 4*. Seven Sisters locality.



A.



B.



C.

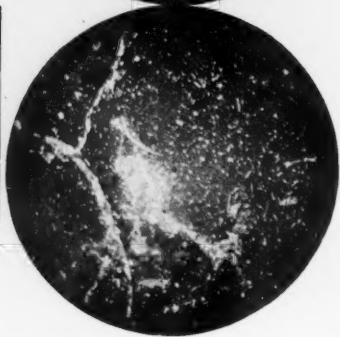


PLATE 10. *Combination Photomicrographs.*

A. *Left:* Buff, coarsely crystalline, sandy, crinoidal limestone containing abundant medium to coarse calcite grains and clear coarsely crystalline calcite.

Right: Medium, subround to round, frosted quartz sand and white, microcrystalline silica as partial replacement of crinoid columnals. Residue is 24% of sample. Fernvale, Murray Lane locality. (Small scale is 4 sq. mm.)

Thin section of A (uncrossed nicols).

a. Dusty crinoid columnal which has clear rim growth. Both rim and columnal, formerly calcite, are now silicified with no destruction of texture.

b. Cracked columnal with calcite filling crack.

c. Transverse section of partly silicified columnal.

d. Oblique section of crinoid columnal.

e. Medium subround to round quartz sand.

f. Trilobite fragment (pleochoic).

g. Clear interstitial calcite crystals. (Opaque square is 1 mm.)

B. *Left:* Buff, hard, microcrystalline to finely crystalline, pseudo-oolitic limestone with relict microgranularity.

Right: Sparse residue of small, white clay pellets and very fine angular, detrital quartz sand. *Member 1.* Murray Lane locality.

Thin section of B (uncrossed nicols).

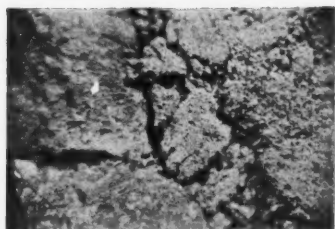
Oolitic texture is caused by pseudo-oolitic clay pellets intimately mixed with microcrystalline calcite. Prominent dark areas contain greater percentages of calcareous clay.

C. *Left:* White lithographic limestone containing scattered nests and individual euhedral dolomite crystals. Veinlets are dolomite in calcite matrix.

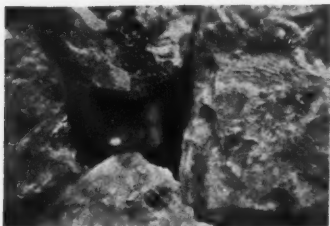
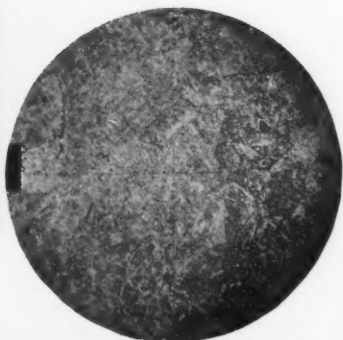
Right: Sparse residue of white clay pellets and pulverulent disseminated clay. Sample 4,224-4,230 feet, *Member 2.* Shell's Mitchell 1, Sec. 3, T. 6 N., R. 4 E.

Thin section of C (crossed nicols).

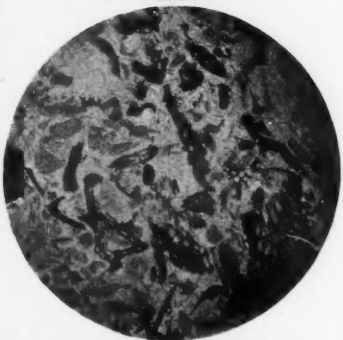
Thin curved flakes of calcite on right. Irregular nests of clear, medium crystalline calcite near center. Calcite veinlets on left contain dolomite crystals. Euhedral fine to medium dolomite crystals scattered through lithographic matrix.



A.



B.



C.

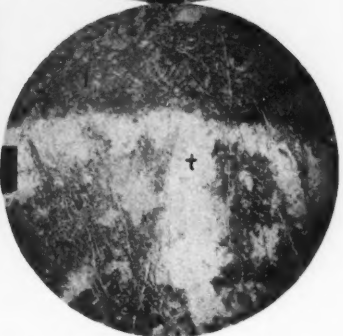


PLATE 11. Combination Photomicrographs.

A. Left: Dark buffish gray, argillaceous, glauconitic, microcrystalline to finely crystalline limestone with scattered fossil fragments.

Right: Mixed silica and plastic clay containing very fine subangular to subround, detrital quartz sand. Residue is 13 1/4% of sample. Member 2, Seven Sisters locality. (Small scale is 4 sq. mm.)

Thin section of A (uncrossed nicols).

Conspicuous fragments of ostracod shells, very fine sand, and medium crystalline clear calcite embedded in matrix of microgranular calcite and clay. (Opaque square is 1 mm.)

B. Light buffish gray, coarsely granular and coarsely crystalline, shell-breccia limestone containing brachiopods, bryozoans, ostracods, crinoids, and unidentified microscopic sponge-like fauna. Sparse residue of white microcrystalline silica not shown. Member 3, Murray Lane locality.

Thin section of B (uncrossed nicols).

Coarsely crystalline, clear calcite matrix encloses coarse, detrital, fossil fragments.

C. Light gray, porcelaneous, subtranslucent, tripolitic chert. Seven Sisters locality.

Thin section of tripolitic contact of C and D, uncrossed nicols.

Limestone (l) shows sharp contact with pure tripoli (t), which contacts chert (c) irregularly showing probable genetic relation between tripoli and thin calcite veinlets (v) on contact. Most of veinlets do not extend into limestone.

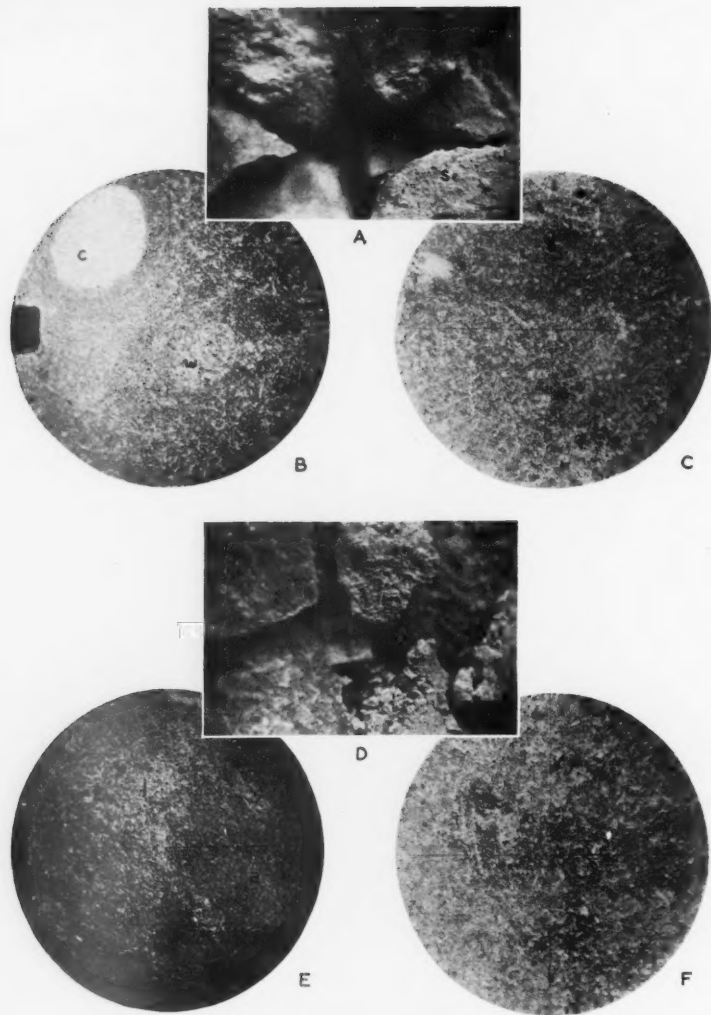


PLATE 12. *Combination Photomicrographs.*

A. *Left:* Buffish gray, hard, pseudo-oolitic, microgranular and resorbed finely granular limestone crystallized in part to microcrystalline texture. Contains oval areas of pure, coarsely crystalline calcite.

Right: Greenish buff, microgranular silica clay (*s*) showing gradual transition into chert (*c*). Residue is 49½% of sample. *Member 4*, Seven Sisters locality. (Small scale is 4 sq. mm.)

B. Thin section of A (uncrossed nicols).

Dark, dusty, clay-filled matrix intimately mixed silica clay and microcrystalline calcite penetrated by oval, tube-like openings (worm borings?) filled with coarsely crystalline calcite (*c*) or finely crystalline calcite mixed with clay (*w*). Most of silica clay is disseminated, whereas some concentrations show minute pellet form. Matrix contains some silica clay converted to pure interstitial silica. Trace of very fine, subangular, detrital quartz fragments. Thin, flat, and curved calcite flakes on lower right. (Opaque square is 1 mm.)

C. Thin section of A (uncrossed nicols; magnification double that of B).

D. *Left:* Buff, microgranular, compact limestone showing microcrystalline texture imposed by crystallization of calcareous sediments intimately mixed with traces of silica clay. Limestone is faintly pseudo-oolitic.

Right: Light buff, pulverulent, microgranular silica clay. Residue is 34½% of sample. *Member 4*, Seven Sisters locality.

E. Thin section of D (uncrossed nicols).

Darker areas show higher concentration of silica and plastic clay (*d*). Light areas are visibly crystallized calcite which gives whole rock "recrystallized" aspect (*h*). Intermediate areas (*a*) are intimate mixtures of micro-calcite and traces of silica clay and plastic clay. Fine subangular to subround quartz sand scattered through matrix (*q*).

F. Thin section of D (uncrossed nicols; magnification double that of E).

SUBSURFACE LITHOLOGIC DESCRIPTION

The abundance of cuttings studied precludes summary description of each test; hence, a general lithologic description is given for each member within a stratigraphic province of the Fernvale and Viola limestone. These provinces are shown in Figure 4, which also shows the traces of regional stratigraphic cross sections. Average thickness of the member in the province is also recorded with the description to facilitate comparisons.

SEMINOLE PROVINCE

- Feet*
- 0- 45 Fernvale limestone; light buffish gray, coarsely crystalline limestone with glauconite and medium subangular to subround sand near the base. Contains detrital shale fragments and pink crystals. Fossils include crinoids, ostracods, brachiopods, graptolites, and corals
- 45- 60 Member one. Viola limestone; buff, micro to finely granular and crystalline limestone with some medium crystalline beds and medium round frosted quartz sand. Fossils include brachiopods, crinoids, and abundant ostracods. Buff, chalcedonic to porcelainous, translucent to subtranslucent, tripolitic chert
- 60-120 Member two. Viola limestone; white to light gray, lithographic to microcrystalline limestone (Pl. 10C). Buffish gray, finely crystalline limestone on the northwest. Persistent lentil of light buffish gray, fine to medium, calcareous dolomite at base. Glauconite and glauconitic green shale near middle and base of member associated with embedded dolomite crystals. Trace of light buff, porcelainous, translucent chert
- 120-185 Member three. Viola limestone; buffish gray to dark gray, microgranular to coarsely granular and crystalline limestone grading northeastward into brown, fine to coarsely crystalline dolomite. Fossils include brachiopods, bryozoans, trilobites, and corals. Milky white to light bluish gray, chalcedonic to granular, translucent to opaque, speckled, spicular chert. Much chert is highly tripolitic, especially where embedded in dolomite. Chert decreases northeastward
- 185-195 Member four. Viola limestone; brown, fine to coarsely granular, siliceous limestone grading to grayish brown, finely crystalline dolomite containing virtually no chert or fossils. This member is absent over much of the Seminole province.

MCALISTER PROVINCE

- Feet*
- 0- 50 Fernvale limestone; white to light gray and buff, medium to coarsely crystalline limestone with some medium to coarsely granular layers. Abundant fine to medium, subround sand and granular glauconite in bottom half of formation. Contains crinoids, ostracods, brachiopods, and graptolites
- 50-105 Member one. Viola limestone; buffish gray, buff, and brown, micro to finely crystalline limestone with some gray mottled, medium to coarsely granular, sandy lentils. Traces of glauconitic shale near top and base. Ostracods, crinoids, brachiopods, corals, bryozoa, and graptolites. Buff, chalcedonic to porcelainous, translucent to subtranslucent, spicular chert. Chert darkens and increases southward
- 105-165 Member two. Viola limestones; brownish gray, fine- to medium-granular and crystalline, siliceous limestone to the south; major part of member is light buff to dark gray, lithographic to microgranular and crystalline limestone toward north. Contains pseudo-oolites and glauconite at base. Ostracods, with some crinoids and brachiopods. Dark gray to brownish gray, chalcedonic to porcelainous, translucent to subtranslucent, waxy, smoky, speckled chert
- 165-240 Member three. Viola limestone; buffish gray to dark brownish gray, fine- to medium-granular and crystalline limestone. Basal part grades northward into brownish gray, medium crystalline, siliceous dolomite. Middle is medium to coarsely granular, highly fossiliferous limestone and some dolomite. Dolomite predominates in north and central McAlester area. Many brachiopods, bryozoans, ostracods, and some trilobites, fish scales, and crinoids. Reddish gray to black, chalcedonic, translucent, smoky, waxy, pyritic chert increasing downward in member and southward in area
- 240-250 Member four. Viola limestone; light to dark gray; microcrystalline and finely granular, siliceous limestone and light gray, fine- to medium-crystalline dolomite. Brachiopods and small ostracods in limestone

FITTS PROVINCE

- Feet*
- 0-70 Fernvale limestone; white to light gray, coarsely crystalline and granular, sandy limestone. Traces of glauconite throughout. Contains crinoids, ostracods, fish scales, gastropods, and graptolites
- 70-140 Member one. Viola limestone; light to dark buff, micro to finely granular and crystalline limestone grading downward to medium granular and crystalline limestone with traces of pseudo-oölites. Thin beds of brown, finely-crystalline dolomite in Franks graben. Fossils include brachiopods, bryozoans, ostracods and crinoids. Buff, chalcedonic to porcelaneous, translucent to subtranslucent spicular, speckled chert. Chert is devitrified and slightly tripolitic where dolomoldal
- 140-200 Member two. Viola limestone.
Southeast.—Light grayish buff, micro to medium granular, pseudo-oölitic limestone with numerous thin beds of brown, finely crystalline dolomite and abundant coarsely granular, highly fossiliferous limestone
Central.—Light buff, micro to finely crystalline, pseudo-oölitic limestone with interbedded gray, medium to coarsely granular, highly fossiliferous limestone and brown, medium-crystalline dolomite
Northwest.—White lithographic to microcrystalline limestone with some light buff, fine- to medium-crystalline dolomite. Lower part of member contains dark green, waxy, fissile glauconite. Member two contains brachiopods, bryozoans, corals, ostracods, and crinoids in coarsely granular layers. Light bluish gray, porcelaneous to granular, subtranslucent, speckled, spicular chert in Franks graben
- 200-280 Member three. Viola limestone; bluish gray to dark gray, micro to coarsely granular, highly fossiliferous limestone with interbeds of brown, fine- to medium-granular and crystalline, calcareous dolomite, and dolomite. Traces of pseudo-oölites and glauconite. Abundant bryozoans, brachiopods, corals, ostracods, graptolites, and crinoids. Bluish gray to grayish blue, chalcedonic to granular, translucent to subtranslucent, highly speckled, spicular, fossiliferous, tripolitic chert
- 280-300 Member four. Viola limestone; light to dark gray, brownish gray to brown, micro- to medium-granular and crystalline, highly variable limestone containing free spicules, black calcareous shale, and interbeds of brown, fine- to medium-crystalline dolomite. Limestone contains trilobites, graptolites, bryozoans, brachiopods, crinoids, ostracods. Lower layers appear to be coarsely granular sedimentary breccia. Dark brown, chalcedonic to porcelaneous, translucent, waxy chert, with some white to light bluish, chalcedonic, translucent, highly fossiliferous, variegated, speckled chert (Pl. 9F)

WAPANUCKA PROVINCE

- Feet*
- 0-95 Fernvale limestone; light buff to dark gray, medium to coarsely granular and coarsely crystalline, sandy limestone containing very coarse detrital calcite grains. Abundant fine to medium, subangular to round, quartz sand in bottom half of formation. Limestone contains crinoids, ostracods, brachiopods, and some bryozoans, gastropods, and corals
- 95-200 Member one. Viola limestone; light to dark buff, micro- to medium-granular and crystalline, sandy, argillaceous, limestone with interbeds of gray, finely crystalline dolomite, and white to buff, medium-crystalline dolomite. Some ostracods, bryozoans, brachiopods, graptolites, and trilobites; fossil content decreases southeast. Lower part, light buff to grayish buff, porcelaneous to microgranular, subtranslucent to opaque, speckled, spicular chert which grades southeastward to dark brownish gray, chalcedonic to granular, subtranslucent, waxy chert
- 200-250 Member two. Viola limestone; grayish buff to brownish gray, micro to finely granular and crystalline limestone with some medium to coarsely granular interbeds containing ostracods, trilobites, and brachiopods. Buff to gray, chalcedonic to porcelaneous, translucent to subtranslucent chert grading southeastward to dark brown, bluish gray, and black, porcelaneous to microgranular, subtranslucent chert
- 250-360 Member three. Viola limestone; buff to gray, grading southeastward to very dark brownish gray and black, finely granular and crystalline, siliceous limestone with traces of dolomite and black oily shale. Brown to black, calcareous siltstone and shale interbeds near base. Traces of brachiopod fragments and small depauperate ostracods. Chert gradation from northwest to southeast as follows: (1) buff to brown, chalcedonic, translucent chert; (2) bluish gray to brownish gray, chalcedonic to porcelaneous, translucent to subtranslucent, waxy, smoky chert; (3) dark gray to black, porcelaneous to granular, subtranslucent to opaque, banded, spicular chert

- 360-400 Member four. Viola limestone; light buff to dark buffish gray, micro to finely granular limestone, interbedded with medium-granular and crystalline limestone, microcrystalline siliceous limestone, and calcareous shale. Limestone contains brachiopods and ostracods. Reddish to bluish brown, and very dark brown, chalcedonic, translucent, smoky, waxy chert

TISHOMINGO PROVINCE

- Feet*
0-30 Fernvale limestone; gray, medium to coarsely granular and crystalline limestone grading southeastward to buffish gray, coarsely granular limestone. Argillaceous streaks near Sylvan contact. Contains crinoids, ostracods, and brachiopods
- 30-140 Member one. Viola limestone; light gray to dark brownish gray, micro- to medium-granular limestone containing some medium crystalline beds. Fossils include brachiopods, ostracods, bryozoans, graptolites, and crinoids. Traces of chert northward; abundant chert southeastward. Light buff to buffish gray, chalcedonic to porcelaneous, translucent, milky to waxy, speckled, spicular chert
- 140-230 Member two. Viola limestone; light to dark buffish gray, microgranular to coarsely granular, highly variable limestone. Giant crinoids, bryozoans, brachiopods, ostracods, and graptolites. Dark reddish buff to grayish brown, chalcedonic to porcelaneous, translucent, waxy, speckled, spicular chert
- 230-400 Member three. Viola limestone; interbedded buff to brown and light to dark gray, micro to finely granular and medium-crystalline limestone with abundant greenish gray, calcareous shale near top of member. Shaly limestone in northwest grades into siliceous limestone on southeast. Contains abundant giant crinoids, ostracods, brachiopods, bryozoans, corals, and some fish scales. Fossils sparse southeastward. Light buff, light gray, buffish to reddish gray, and dark gray, chalcedonic to porcelaneous, translucent, spicular, speckled, waxy chert
- 400-550 Member four. Viola limestone; dark grayish buff to brownish gray, micro to finely granular and crystalline, siliceous limestone with some black and brown shale. Abundant silica clay in northeast part of province grades westward and southeastward to highly cherty limestone. Bryozoans, brachiopods, ostracods, trilobites, crinoids, and fish scales. Dark bluish and brownish gray, chalcedonic to porcelaneous, translucent to subtranslucent, speckled chert grading downward into dark reddish gray, chalcedonic, translucent, waxy chert

ARDMORE PROVINCE

- Feet*
0-20 Fernvale limestone; gray to dark brownish gray, medium-granular to coarsely crystalline limestone with thin, black, argillaceous limestone and shale partings. Contains graptolites and brachiopods
- 20-155 Member one. Viola limestone; light gray to dark reddish and brownish gray, microgranular to finely crystalline, siliceous, argillaceous, and cherty limestone. Where limestone is highly siliceous, very little chert is found. Light buff to buffish gray, micro- to medium-granular limestone in T. 6 S., R. 6 E., is extremely cherty. Traces of gray shale containing depauperate ostracods. Brachiopods, trilobites, and graptolites. Dark bluish, brownish, and reddish gray, chalcedonic to porcelaneous, translucent, calcitic to waxy cherts. Cherts and limestone are cleanly separated and interbedded
- 155-265 Member two. Viola limestone; dark reddish to brownish gray, micro- to medium-granular and crystalline, siliceous limestone with black, siliceous, shale interbeds. Contains brachiopods, trilobites, ostracods, and fish scales. Trace of brown to reddish gray, chalcedonic to porcelaneous, translucent to subtranslucent chert grading southeastward to more abundant buffish gray, chalcedonic, translucent, waxy chert
- 265-470 Member three. Viola limestone; very dark reddish gray, micro to finely granular and crystalline, siliceous limestone interbedded with very dark gray, calcareous, siliceous shales. Fossils include trilobites, ostracods, graptolites, and small gastropods. Traces of dark reddish gray to black, porcelaneous to granular, translucent to opaque chert. Gray, fine- to medium-granular and crystalline, siliceous limestone in T. 6 S., R. 6 E.
- 470-675 Member four. Viola limestone; reddish gray, microcrystalline, highly siliceous limestone in upper part; dark brown to dark gray, micro to finely crystalline, argillaceous and siliceous limestone in middle part; and very dark brown, highly siliceous limestone interbedded with black, microcrystalline, highly argillaceous, siliceous limestone, and calcareous claystone in lower part. Three constituents are interbedded with sharp contacts: (1) highly siliceous limestone, (2) black chert, (3) and brown, bituminous, calcareous claystone. Dark reddish to steel gray, chalcedonic, translucent chert and black, porcelaneous to granular, opaque, bituminous chert abundant near base of member

TABLE III
LIST OF TESTS

TEST No. Sym.	CONTRACT	FASE	No.	LOCATION		EXTENSION	VICINITY	INTERVAL	CASE	L.P.	PROMOTION	COMPLETION
				Section	Top	Rug					Interval	Date
1. (C)	Blade-Jynch Thompson		1A	SV SE SW 1	1E	7E	764	4260 - 4308	4268	4658	63	3833-4109
2. (C)	Mid-Continent Stealer		2	SE SE SW 2	1E	7E	766	4204C/ 4370	4220	4655	1578-15.5	4516-37
3. (C)	Blackstock Thompson		1	SE SE SE 4	1E	7E	772	41650- 4490	4167	4591	94	3725-3736
4. (C)	Continental McCarty		1	SE SE SW 12	1E	7E	747	3900 - 4161	3914	?	5283	4628-4633
5. (C)	Paramount Graham		1	SV SE SW 13	1E	7E	775	2267 - 3138	2268	3478	IMA	-
6. (C)	Sinclair-Prairie Culver		1	SE SE SW 16	1E	8E	668	5040 - 5120	-	5766	...	11-20-36
7. (C)	Continental King		1	SE SE SE 26	1E	8E	655	4830E- 5144	-	5762	69	385-5420
8. (C)	Continental Maciel		1	SV SE SW 27	1E	9E	622	6390 - 6669	-	7195	IMA	-
9. (C)	Delaney Hemigan		1	Center	8	2E	6E	Surf.-300	-	945	IMA	-
10. (C)	Miss Marie McPhist		1	SE SE SE 11	2E	6E	811	642- 795	-	975	IMA	-
11. (C)	Oppy Emery		1	SV SE SE 15	2E	6E	968	5975- 6108	-	6600	IMA	-
12. (C)	Goodhouse Booth		1	SE SE SE 20	2E	6E	1131	4350 - 4819	-	4966	89	4958-4966
13. (C)	Wagnolia Craddock		1	SE SE SE 24	2E	6E	755	4143 - 4416	-	4528	600	5000-403
14. (C)	Delaney Craddock "A"		1	SV SE SE 25	2E	6E	794	3916- 4196	3923	4427	7888	3923-4400
15. (C)	Shelly Akers		1	SE SE SE 36	2E	6E	887	4037 - 4405	4048	4425	1512	4048-4321
16. (C)	Simpson-Goodhouse McKay		1	SV SE SE 1	2E	7E	752	2251 - 2265	-	2859	IMA	-
17. (C)	Moore Walte		1	SV SE SW 8	2E	7E	733	890 - 1145	-	2315	IMA	-
18. (C)	Blackstock Moody		5	SE SW SW 23	2E	7E	674	4022 - 4275	4040	4391	826	4040-4257
19. (C)	Amerasia Smith		1	SE SW SW 28	2E	7E	706	3640 - 3923	3651	4159	1608	3646-3923
20. (C)	Moore Smith "A"		7	SV SE SW 31	2E	7E	833	3658 - 3945	3691	4402	8352	3651-3945
21. (C)	Danner-Moore Edwards		1	SV SE SE 27	2E	8E	713	6762- 7000	6772	7336	IMA	-
22. (C)	" Carter Note		1	CS SE SW 19	2E	9E	706	6600 - 6830	-	7374	IMA	-
23. (C)	Carter Claytor		1	CS SE SW 27	2E	9E	714	6008 - 6263	6016	6722	165	6108-6263
24. (C)	Carter Thompson		1	CS SE SW 34	2E	9E	699	5970 - 6238	5993	6726	60	4800-4898
25. (C)	Crescent Thompson		1A	SE SW SW 29	3E	4E	1101	41365 - 41.4	1320	1675	IMA	-
26. (C)	Ridale Fee		1	SV SW SE 11	3E	5E	937	4115 - 4410	-	4410	IMA	-
27. (C)	Sandback Sands		1	SE SE SE 20	3E	5E	1089	926 - 1270	926	1907	IMA	-
28. (C)	Ada Simons		1	CS SE SW 8	3E	6E	1010	4149 - 4528D	-	4887	IMA	-
29. (C)	Union Abbott		1	SV SW SE 34	3E	6E	834	703 - 1027	-	3300	IMA	-

30. ⑤ Ramsey Johnson	1	NV SV SE 9 3E	7E	871	2050 - 2300	2055	28+5	1.5	1058-1069	2- 9-37
31. ⑤ Stanfield Oushing	1	NV SE SE 22 3E	9E	722	4920 - 5155	-	?	DAA	-	?
32. ⑤ Carter Varne	1	SE SE NV 31 3E	9E	695	5218 / 5422	-	5935	DAA	-	2- 2-37
33. ⑤ Shell Hill "A"	4	Center NV 30 3E	10E	761	5489 M 5675	-	5902	?	?	?
34. ⑤ Peckham-Harris Hollins	1	OSL NV NV 11 4E	1E	1024	?	-	4667	DAA	-	4- 7-30
35. ⑤ Dixie Perkins	1	SE SE NV 15 4E	1E	1015	FW200 - 4383	-	5455	DAA	-	5-21-28
36. ⑤ Tidewater Sturdevant	1	SE SE NV 28 4E	1E	941	FW147 - 4355	-	4549	DAA	-	10-19-36
37. ⑤ Huckleberry Wood	1	SE SE NV 5 4E	3E	1132	3160 - 3467	-	3837	DAA	-	2-23-37
38. ⑤ Midco Clay	1	SV SV NV 21 4E	3E	1153	22815 - 3145	-	3503	DAA	-	1- 9-40
39. ⑤ Maryland Korrance	1	Center SE 10 4E	4E	1109	21758 - 1993	1759	2196	DAA	-	4- 2-28
40. ⑤ McBride Chester	1	SE SE SE 26 4E	4E	1035	1520 - 1799	1787	1879	DAA	-	4-10-35
41. ⑤ Peepose Jones	1	SV SV NV 2 4E	5E	970	2595 - T.D.	-	2853	DAA	-	6- 1-37
42. ⑤ Marchant Phillips	1	OSL NV SE 8 4E	5E	1046	1740 - 2005	-	2160	DAA	-	10-17-39
43. ⑤ Fleetborne Oliver	1	SE NV SE 21 4E	5E	965	1807 - 2077	-	2229	DAA	-	6- 4-35
44. ⑤ Carter-McBride Copeland	1	SE SE NV 31 4E	5E	972	1534 - 1942	1690	2100	DAA	-	10- 1-35
45. ⑤ Sinclair Gardner	1	SE SE NV 6 4E	6E	875	2220 - 2854	2629	2975	DAA	-	4-23-29
46. ⑤ Dixie Sales	1	SE SE NV 10 4E	6E	927	28450 - 2887	2673	?	DAA	-	8-11-27
47. ⑤ Blackwell Mount	1	SV SV NV 13 4E	6E	976	3130 - 3370	-	3470	20	1530-1560	6-29-37
48. ⑤ Summit Whitaker	1E	NV SE SE 31 4E	6E	890	2815 / 2983	-	3754	DAA	-	6-15-37
49. ⑤ Verthaler-Tubbs Smith-Lee	1	SE NV NV 10 4E	7E	907	38250 - 4042	-	4132	DAA	-	6-18-29
50. ⑤ Bosticher Sledge	1	SE NV SE 25 4E	7E	796	4214 - T.D.	-	4347	DAA	-	12-21-37
51. ⑤ Lynch Parker	1	SV SV SE 17 4E	8E	791	4250 - 4440	4270	4572	DAA	-	8-22-38
52. ⑤ Delaney Richardson	1	SE SE NV 30 4E	8E	814	4355 - 4578	-	4760	DAA	-	7-26-37
53. ⑤ Continental Hudson	1	SE SE SE 8 4E	9E	891	5820 - 6008	-	6330	DAA	-	7- 3-39
54. ⑤ Moore Hunter	1	SE SE NV 30 4E	9E	712	5810 - 5598	-	5949	DAA	-	4-26-38
55. ⑤ Carter et al Hamilton	1	OSL NV 33 4E	9E	808	5590 - 5780	-	6177	DAA	-	?
56. ⑤ Anderson-Kerr Riley	1	SE SE NV 2 4E	1E	1006	25280 - 5589	-	5776	DAA	-	3-19-35
57. ⑤ Denver Herbert	1	Center NV 22 5E	1E	1118	5904 - 6240	-	6355	DAA	-	8-14-34
58. ⑤ L.T.L.O. Lambert	1	OSL NV 6 5E	2E	1047	5820 - 5580	-	5716	DAA	-	6-27-39
59. ⑤ Blackwell Neal	1	NV SE NV 4 5E	3E	950	3777 M 4070	3798	4212	25	2655-2668	5-14-35
60. ⑤ Anderson Western	1	SV SV SE 24 5E	3E	1033	22653 - 2820	-	2941	DAA	-	5-21-35

INDEX No. Sys.	COMPANY	LEASE	NO.	LOCALITY Section Top	ELEVATION Top	WATER INTERVAL	CASING	I.P. Interval	COMPLETION Date
61. (C)	Empire Bonner		1	SE 1/4 SW 29 58 38	1107	4412 - 4680	4473	MAA -	?
62. (C)	Snyder-Lynch Herby		1	SE 1/4 SE 24 58 48	934	2313 - T.D.	2313	25	2312-2512 7-22-31
63. (C)	Senora Standridge		1A	SW 1/4 SW 26 58 48	1016	2520 - T.D.	2520	MAA -	7-9-40
64. (C)	Grimes Dye		1	SE 1/4 SE 2 58 58	899	3040 - 3275	-	3379	MAA - 3-25-39
65. (C)	Farmers Mutual Shaw		1	SE 1/4 SW 9 58 58	975	2879 - 3130	-	3524	120 2720-2745 9-12-38
66. (C)	Shaffer Isaac		1	CO 1/4 SE 13 58 58	984	2865 - 3097	-	3203	MAA - 4-24-28
67. (C)	Bendum-Trees Easely		1	SE 1/4 SW 27 58 58	1003	2855 / 2945	2856	3010	MAA - 3-18-30
68. (C)	Bendum-Trees Burke		1	SE 1/4 SE 32 58 58	1008	2517 / 2705	2675	2765	MAA - 1-19-32
69. (C)	Slick Barnett		1	SE 1/4 SW 13 58 68	84	3643 - 3860	-	?	MAA - 4-24-28
70. (C)	Stonewall Hasty		1	SE 1/4 SE 16 58 68	897	2953 - 3165	-	3244	MAA - 12-12-39
71. (C)	Stanford-Merada Aldridge		1	CO 1/4 SE 2 58 72	922	4345 - 4286	-	4295	17 2618-2695 3-27-34
72. (C)	Magnolia Whitney		1	SW 1/4 SE 24 58 72	845	4120 - T.D.	-	4293	MAA - 5-5-31
73. (C)	Universal Slater		1	SW 1/4 SW 31 58 72	989	37501 - 2962	3755	4093	MAA - 9-9-30
74. (C)	Feckum-Harris Corbett		1	SE 1/4 SE 20 68 118	1058	6310 - 6620	6320	6760	MAA - 1-13-31
75. (C)	Kell-Briscoe Mantrouth		1	SW 1/4 SW 24 68 118	1031	5950 - 6290	-	6387	MAA - 7-25-39
76. (C)	Cities Service Landrand		1	SE 1/4 SW 27 68 22	1033	4894 - 5140	4948	5304	51 5113-5130 10-5-43
77. (C)	Shaffer Adams		1	SE 1/4 SE 11 68 38	1101	4430 - 4631C	-	4632	MAA - 10-7-29
78. (C)	Phillips(Tlyn) Ford		1	SE 1/4 SW 17 68 38	1045	4315 - 4565	4412	4472	MAA - 9-25-34
79. (C)	Nash Miller		1	CO 1/4 SE 29 68 38	1038	4025 - 4328	4296	4415	MAA - 10-5-37
80. (C)	Grison et al Ladema		1	SE 1/4 SW 33 68 38	1000	3880 - T.D.	-	4158	MAA - 1-14-41
81. (C)	Shall Mitchell		1	SE 1/4 SE 3 68 48	1106	4167 - T.D.	4172	4310	?
82. (C)	Magnolia Harris		1	SW 1/4 SW 6 68 48	1037	4025 - 4420	-	4463	MAA - 5-13-31
83. (C)	Magnolia Vest		1	SW 1/4 SE 22 68 48	986	3520 - 3760C	-	3735	MAA - 2-18-36
84. (C)	Arrow-Shall Gremien		1	SE 1/4 SE 26 68 48	925	3470 - 3743	-	3804	50 2877-2920 8-9-32
85. (C)	Alma Johnson		1	SW 1/4 SW 19 68 58	980	3665 - 3915	-	4062	231 2890-2900 9-5-39
86. (C)	O'Ware-Hall Shaw		1	SE 1/4 SE 32 68 58	981	3010 - 3267	-	3346	MAA - 3-21-38
87. (C)	Pine Barber-Jason		1	SE 1/4 SW 16 68 68	948	3375 - 3584	-	3779	?
88. (C)	Rosey Harjo		1	SW 1/4 SE 24 68 68	900	3990 - 4149	-	4174	MAA - 11-25-41
89. (C)	Kingswood Dodson		1	SE 1/4 SE 28 68 68	912	3636 - 3855	-	3958	MAA - 7-7-36

90. ④ Palmetto Cherty	1	Cent SW 33 68	68	930	3325 - 3520	-	4009	DAA	-	12- 1-36
91. ④ Armstrong et al. Diamond	1	EE SE SW 8 68	78	807	3870 - 4010	5918	4044	DAA	-	9-19-33
92. ④ Arab Yuhai	1	SE SE SW 16 78	18	1216	6538 - 6704	-	6090	DAA	-	10- 1-35
93. ④ Shell Hurst	1	SE SW 17 78	28	1138	5885 - T.D.	-	6098	DAA	-	2-11-29
94. ④ Wood Gully	1	SW SW 34 78	58	959	6128 - 4323	-	4011	DAA	-	6- 7-38
95. ④ Delaney Bugher	1	SE SE SW 12 78	28	1108	7305 - 7575	7445	7682	768	2445-7626	8-10-38
96. ④ Hollenbeck Stinson	1	SW SW 17 98	28	1161	7275 - 7565	-	7695	DAA	-	10- 6-37
97. ④ Sinclair-Prairie Husman	1	SW SE SW 21 108	28	1231	7138 - 7365	7140	8025	DAA	-	12-18-35
98. ④ Sinclair Lancaster	1	Cent SW 10 18	28	901	3380 - 3688	-	4404	DAA	-	10-26-37
99. ④ Carter Vinsonite	1	SW SE SW 34 18	28	845	10 - 588	40	2905	DAA	-	4- 4-39
100. ④ Masahan-Miller Ward	1	EE SE SW 18 18	38	857	6308 - 1168	-	2110	DAA	-	4-16-35
101. ④ Equitable Ferguson	1	EE SE SW 36 18	38	974	462 / 775	-	2824	DAA	-	9- 3-35
102. ④ Delaney Blumund	1	SW SW SE 5 18	88	797	1848 - 2128	1948	2672	DAA	-	3- 5-35
103. ④ Southern Fish	1	SW SW SW 6 18	88	820	6700-956	-	?	DAA	-	1-21-36
104. ④ Carter-Magnolia Jones	1	SW SW SW 35 18	88	675	2858 - 3185	2905	3784	DAA	-	8-25-36
105. ④ Asarda-Stanolind Travelers	1	SW SW SE 28 18	98	607	4467 - 4772	4491	5016	DAA	-	8-20-35
106. ④ Equitable Belleley	1	SE SE SW 12 28	48	1001	Surf. - 5530	-	2023	DAA	-	1-28-36
107. ④ Shell Illinois Bankers Life	1	Cent SE 10 28	78	734	815 - 1245	814	2100	DAA	-	?
108. ④ Magnolia Green	1	EE SE SE 12 28	78	704	1560 - 1933	1567	2615	DAA	-	5-19-36
109. ④ Oklahoma Mayhubb	1	SW SE SE 11 28	88	631	2872 - 3194	-	3782	DAA	-	9-18-34
110. ④ Old American Investment	1	SW SE SE 26 28	88	645	1430 - 1803	-	2446	DAA	-	11-27-34
111. ④ Pure Noble	1	Cent SE 35 38	18	797	5015 - 5739	-	8501	DAA	-	?
112. ④ Riverland Jones	1	SW SW SE 4 38	98	582	1763 - 2100	1749	2728	DAA	-	6- 9-36
113. ④ Asarda Ridgeway	1	SW SE SE 24 38	98	606	2650 - 3023	2730	4879	DAA	-	5-17-38
114. ④ Prairie Cobb	1	SW SE SW 19 38	118	531	35 - 463	32103	720	DAA	-	11-17-36
115. ④ Gilmore Lee	1	EE SW SW 2 48	108	535	1208 - 1605	13681	3455	DAA	-	10-18-38
116. ④ Pure Little "166"	1	SW SW SW 27 58	78	596	5940 - 4480	-	5080	288	4883-5080	11-26-40
117. ④ Johnson-Lewis Godfrey	1	SW SE SE 14 68	68	637	2627 - 3590	-	5990	DAA	-	7- 2-40

Explanations

- Single circle with R and C examined with binocular microscope
Double circle with R and C insoluble residues prepared
- Explanations**
- D - Violent section with recognizable dip
E - Errors caused by mis-orientation
P - Pennsylvanian rocks on Viola limestone
/ - Faulted section
Producing interval underlined above
C - cable tool E - rotary tool

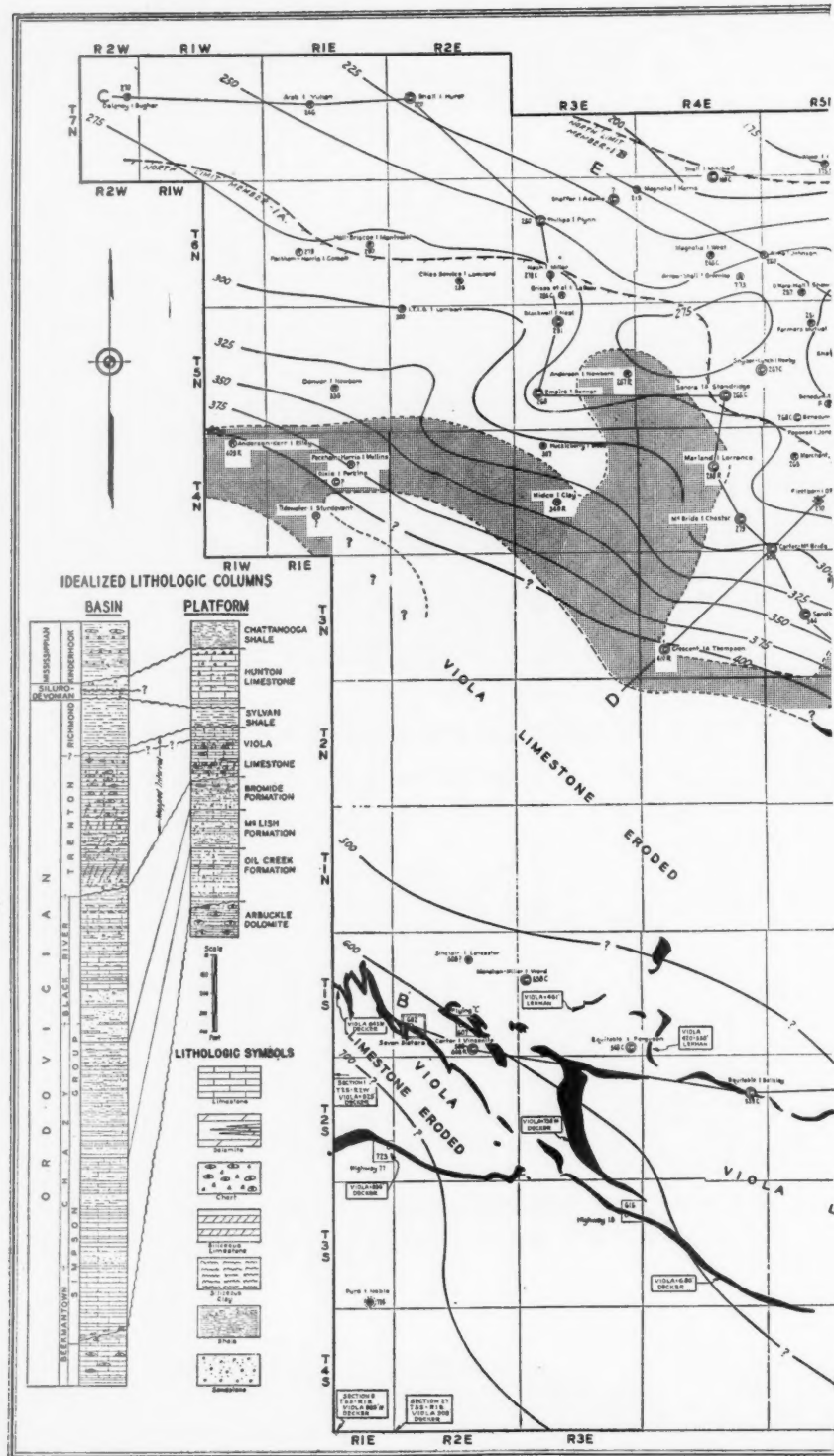


FIG. 6.—Thickness of

Member four grades southeastward to gray, fine- to medium-granular and crystalline, highly cherty limestone. Chert is reddish smoky black, porcelainous, and subtranslucent. Though limestone is relatively silica-free where chert-free, total silica content of member is remarkably constant in northwest-southeast trends.

REGIONAL CONSIDERATIONS

MASS CHARACTERISTICS

COLOR

The Fernvale and Viola limestones are predominantly buff and gray in south-central Oklahoma. The formations as a whole grade from lighter shades of color on the northeast to darker shades in the southwest. A second major gradation occurs on the east and southeast side of the area, where darker shades of buff and gray in the McAlester area grade southward to pure yellow-brown (buff) in the Wapanucka area. Southeastward from that area, an abrupt change to dark gray, shaly, Viola limestone is notable in samples from wells northwest of the Ouachita front.

TEXTURE

The Fernvale limestone is coarsely crystalline and granular throughout the area north of the Arbuckle Mountains. The texture grades from coarsely crystalline to medium-crystalline and granular southwestward in the Arbuckle Mountains.

The Viola limestone is generally paurograined in texture on the Seminole platform at the northeast and in the Ardmore basin at the southwest, with an important concentration of megagrained textures in the Fitts-Wapanucka area and in some beds in the Arbuckle Mountains. Mesograined textures are quantitatively less important in much of the area of study, excepting in the dolomites northeast of the Arbuckle Mountains.

THICKNESS

The Fernvale and Viola limestones, combined, thicken southwestward from the Seminole platform to the Ardmore basin (Fig. 6). The Fernvale limestone itself is thin in the Ardmore province (Fig. 7). Isopach data are sparse in the Arbuckle Mountains because few geologists have published the thicknesses of carefully measured Viola sections. The Viola isopach map constructed for this study also shows Decker's published data and the measurements made by Lehman (Decker, 1933, p. 1411; Lehman, 1945, p. 193). The general thicknesses given by Taff in his regional work are not placed on the map, because of his original error in defining the lower Viola contact and the lack of specific locations for the measurements.

Widely spaced isopachs characterize the Seminole and McAlester areas. An anomalously thin Viola section occurs in the Franks graben, from which the formation thickens southward to the north limb of the Hunton anticline. Similar but less drastic southward thickening occurs on the boundary between the south side of the Wapanucka graben and the north limb of the Belton anticline. The

SUBSURFACE STRUCTURE

CONTOUR INTERVAL 500 FEET

SCALE

Miles

LEGEND

Rotary Tests

- ① Lithologic Examination
- ② Quantitative Insoluble Residue Analyses
- ③ Qualitative Insoluble Residue Analyses

Cable Tool Tests

- ④ Lithologic Examination
- ⑤ Quantitative Insoluble Residue Analyses
- ⑥ Qualitative Insoluble Residue Analyses

Field Sections

- Lithologic Examination
- Quantitative Insoluble Residue Analyses
- Upper Contact of the Viola at the Collected Section.

Outcrop of Viola

Subcrop of Viola
Beneath Pennsylvanian Strata

CONTINUED ON TOP OF PAGE 10
FRACTION - Showing Location of Open-Profile
Box 8, 1/2 mile top of First Surface
1234 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 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Viola section on the north limb of the Arbuckle anticline is notably thicker than that in the Washita syncline or the Dougherty anticline, suggesting an anomalous relation like that along the north edge of the exposed mountains. Comparison of the Fernvale-Viola isopach with the Fernvale isopach map shows that several anomalous re-entrants northeast and north of the Arbuckle Mountains are caused by locally thin Fernvale limestone which is disconformably overlain by Sylvan shale.

STRUCTURE

Generalized structure of the Fernvale-Viola limestone is shown on the sub-surface structure map, which is contoured on top of the Fernvale limestone (Fig. 8). No effort was made to show the structure where the formation is at the surface, but the major structural features are labelled on the structural map. The relation of the Viola subcrop to the buried northwestern Arbuckle Mountains is clearly shown in the north-central part of the map. The McAlester basin, formed subsequent to Viola time, is a westward extension of the Arkansas-Oklahoma coal basin. A comparison of the structural and isopach maps proves that the present structural features are entirely post-Fernvale in age and that they are not reflections of any orogenic movements affecting the floor of the sea during Fernvale or Viola time.

TOTAL INSOLUBLE RESIDUE

The quantity of insoluble residue in the Fernvale and Viola limestones increases southwestward without great anomalies. (See Fig. 9). The area of low insoluble-residue content extends across the Seminole and McAlester areas, whereas the area of highest insoluble-residue content parallels the old Arbuckle geosyncline (approximately parallel with the Ardmore basin), and extends southeastward to the Ouachita front. The great increase in total residue in the Ouachita facies is entirely anomalous in relation to the greater total residue discovered in the deepest parts of the old Arbuckle geosyncline.

Regional distribution of insoluble-residue content is geographically related to the Arbuckle Mountains and the subcrop of Fernvale and Viola limestones in the buried northwest extension of the Arbuckle Mountains. The relation has no genetic significance, inasmuch as the higher Arbuckle folds were coincidentally formed from the deeper parts of the Arbuckle geosyncline where greater concentrations of insoluble-residue constituents are normally found in thick Viola limestones. That the relation is casual rather than causal is aptly proved by the existence of similar insoluble residues in compact Viola limestones on the limbs of the Arbuckle folds and deep in the subsurface in grabens and synclines within and outside the Arbuckle Mountain area.

TOTAL CHERT

The insoluble-residue map shows a general southwestward increase in total residues composed mainly of chert and silica clay. The Viola chert map, however, shows some striking variations in chert content (Fig. 10). The silica which should

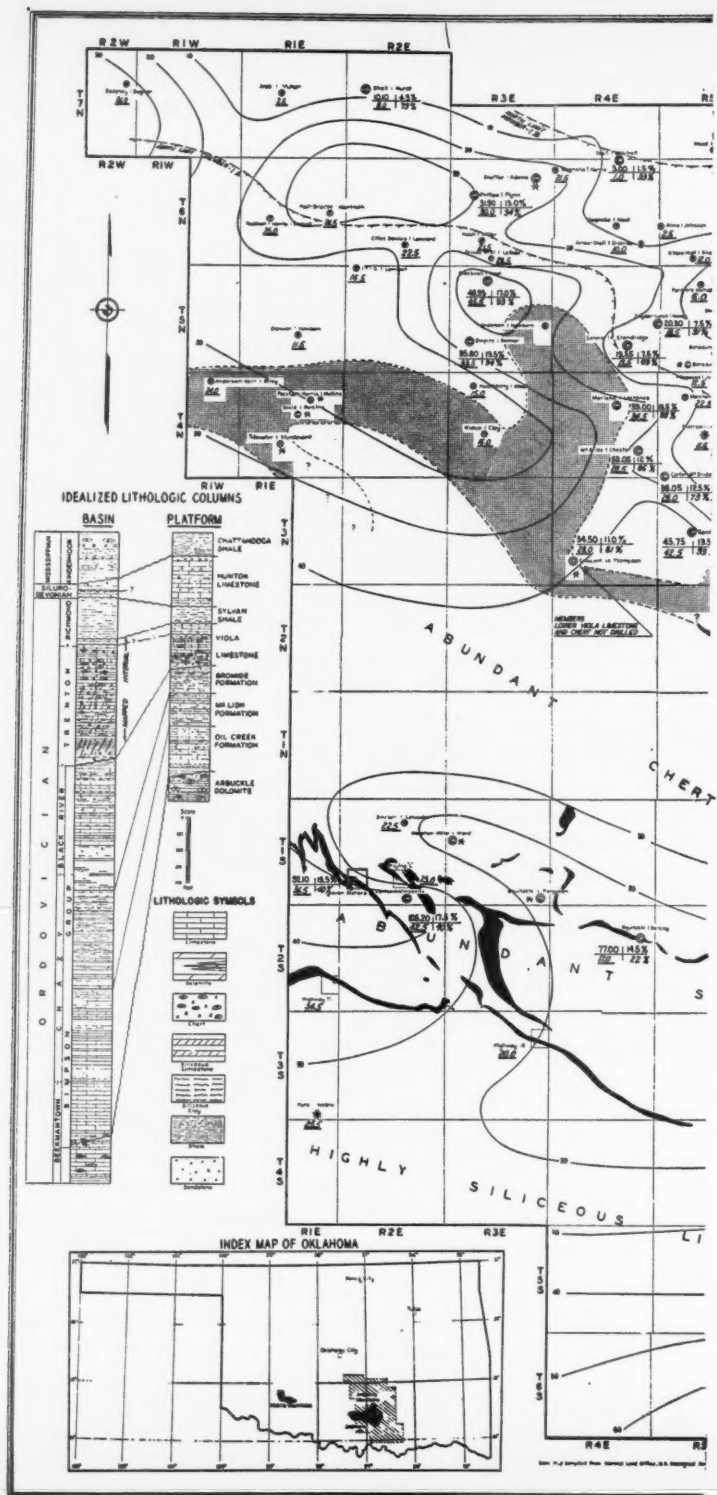


FIG. 10.—Chert in

be present as chert is in the form of unrecognized calcareous silica clay, an admixture of microcrystalline quartz and calcium carbonate, which does not look like true chert in the field or in the cuttings. Silica clay, because of its calcitic texture, ordinarily can not be recognized without insoluble residues.

The wide area of low chert content extending from the Mill Creek syncline to the Wapanucka graben reveals an important concentration of silica clay grading into chert and highly siliceous limestone in the south and southeast parts of the area. Thus, though the insoluble-residue map shows a general southwestward increase in total residues, the chert map reveals a great northwest-trending anomalous area of low chert content parallel with the north flank of the Arbuckle geosyncline, the former presence of which may be recognized from Viola isopach data. The difference is almost wholly caused by an apparently incomplete transition of original silica to true chert, whatever may have been the syngenetic, diagenetic, or epigenetic process or processes causing the formation of chert. *The most important feature on the chert map is the lack of coincidence between areas of high chert content and areas exposed to erosion at any time in geologic history.*

DOLOMITE

Dolomites of the Viola limestone are concentrated in the north-central part of the area of study. There is a gradual transition from the thick calcareous Viola section of the basin, northeastward to the thin dolomitic Viola section of the platform. The dolomite is almost invariably found in the lower half of the Viola limestone. *The distribution of dolomite shows no coincidental geographic relation to areas of the Viola limestone exposed to erosion at several times throughout geologic history.*

SHALE AND SAND

The total content of argillaceous material, either admixed with limestones to form argillaceous limestone or as shaly layers composed of calcareous claystones, increases southwestward from the Seminole platform to the Arbuckle geosyncline. Fine to medium sands distributed throughout the Viola limestone and the basal Fernvale limestone are not plentiful in the Fitts-Wapanucka province, though much very fine, subangular, detrital quartz sand is found in the thick basin sections of the Viola limestone.

DETAILED SUBDIVISION

CORRELATION OF HORIZONS

Correlation of members within the Viola limestone is not a simple matter of dividing each studied Viola section into lithologically similar beds and sliding logs to find equivalent sequences. Nor is correlation the selection, from data from a single well, of stratigraphic breaks by lithologic criteria alone. Correlation and subdivision are inseparable techniques which comprise lateral qualitative and quantitative comparison, as well as vertical qualitative and quantitative differentiation by means of lithologic characteristics. Correlation and subdivi-

sion are, in the last analysis, *results* of the application of those techniques to an orderly physical assembly of geologic data.

Correlation and subdivision of a formation must be carried forward simultaneously, inasmuch as the subdivision of a laterally grading formation such as the Viola limestone can only be done accurately by comparisons between adjacent sections. A dynamic balance must be established between arbitrary subdivision, based on lithologic features alone, and the highly arbitrary assumption that lateral gradations within a formation destroy the value of subdivision. Regardless of synchronicity, certain mass lithologic features appear to be correlatable over wide areas if quantification had been applied to the sedimentary data. The surfaces between these mass lithologic features may or may not be disconformities representing hiatuses of differing time-length resulting from epeirogeny or orogeny and concomitant eustatic or isostatic shifts in the relative level of land and sea. Fossils provide the only relatively reliable time measure of hiatus (Twenhofel, 1939, p. 518). Whether or not such a surface represents a halt in sedimentation, it is important to realize that it separates two groups of strata of differing character and content in wide areas. The lithologic criteria for recognition of subsurface unconformities have not yet been completely established, although Krumbein has tabulated the criteria most frequently mentioned in published reports (1942, p. 38).

Present knowledge of the length of time represented by what is *not* present between two groups of strata can be only inferential and must be related to some other area where faunal content proves that continuous succession is present. If erosion occurred, inferences can seldom be made about the cause, whether subaerial or submarine, unless a considerable amount of sediment or rock has been removed.

In this study two surfaces are involved: the surface, notable because of change in the type of sediment deposited, whatever the cause; and the surface, caused by non-deposition or erosion. The first surface has no recognized name*and is but a correlator's tool to separate two masses of strata that appear to be members which can be recognized in a wide area. The non-committal phrase, *inter-member surface*, is proposed for all surfaces between members of the Viola limestone. Several surfaces within the Viola limestone are definitely the result of non-deposition or erosion and they can be labeled *disconformities*. Definition of this second type of surface is based on a combination of regional correlative data and detailed lithologic characteristics in the member immediately above and the member immediately below the disconformity.

PHYSICAL SUBDIVISION

The vertical intercept of subdivision (thickness) of a recognizable member in a formation, penetrated during drilling operations, depends on three prime factors.

Sample interval.—If samples are taken every 20 feet, it is sheer folly to subdivide a formation into members less than 40 feet thick, because at least two successive samples are needed to establish and define lithologic character and

contacts in any well. A near-by test may be drilled at larger or smaller intercepts or even have a sample skip in that interval. Samples from Viola limestone average 6.5 feet of section per sample, with sample intervals ranging from 1 to 20 feet.

Spacing of tests.—The geometry of sampling requires a rather regular spacing of wells to lend validity to interpolated correlations in an area and extrapolated correlations around the edge of a chosen area. The tests chosen should be spaced somewhat uniformly in order that the lithologic characteristics, noted in one area,

TABLE IV
FIELD SECTIONS OF FERNALE AND VIOLA LIMESTONES
(Thicknesses in feet)

Unit	Murray Lane*	Robertson Creek*	Flying "L"*	Highway 18*	Seven Sisters*	Highway 77*
Fernvale	80	99	12	19	26	21
1A.	57	48	64	56	54	59
1B.	56	55	66	73	59	57
2.	72	65	88?	96	107	125
3A.	47	54	84?	88	106	123
3B.	36	55	81	115	96	112
4.	54	58	212	168	234	226
Total	402	434	607	615	682	723

* Field Sections.

TABLE V
AVERAGE THICKNESSES OF FERNALE AND VIOLA SUBDIVISIONS
(Thicknesses in feet)

Unit	Ardmore*	Tishomingo*	Wapanucka*	Fitts*	McAlester*	Seminole*
Fernvale	20	30	95	70	50	45
1A.	65	50	55	30	25	absent
1B.	70	60	50	40	30	15
2.	110	90	50	60	60	60
3A.	100	80	50	40	35	35
3B.	105	90	60	40	40	35
4.	205	150	40	20	10	10
Total	675	550	400	300	250	200

* Stratigraphic provinces.

may be recognized in an adjacent area, and the lateral variation noted for projection to a more distant area. If intermediate areas are undrilled, a vital point in the gradational series is not available and one sampled section may look entirely different from another some distance away, with no recognizable clues available for subdivision and correlation. This very factor has led commercial stratigraphers to note the difficulty of bridging the broad eroded area of the Arbuckle Mountains in correlating subsurface formations of the Seminole area with subsurface formations of the Ardmore basin. This blank area lies directly athwart that part of the depositional basin in which the southwest-trending line of maximum sedimen-

LIMESTONES OF SOUTH-CENTRAL OKLAHOMA

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TABLE VI
CRITERIA FOR SUBDIVISION OF FERNVALE AND VIOLA LIMESTONES

CONTACTS	CRITERIA	% Residue	% Chert	Texture	Color	Silica	Fossils	Chert type	Band	Clauconite	Silica clay	Plastic clay	Dolomite	Tripoli	Pyrite	Parallelism	Shale	Pseudo-collies
Fernvale F-1A																		
Seminole(F-1B)		0	0	0	0	x	x			x								
McAlester		0	0	0	0	x	x		0	x								
Fitts		0	0	0	0				x	x					x		x	
Wapanucka	x	0	0	0	0	x	0		0			x				x		
Tishomingo		0	0	0	0													
Ardmore		0	0	0	x												x	
Member 1A-1B																		
Seminole			x	x			x					Unit 1A						
McAlester		0	0	0			x		x	x								
Fitts	0	0	0	0					x				x		x			
Wapanucka	0	0	0	0	x		x		0									
Tishomingo	0	0	0	0												x		
Ardmore	0	0	0	0	x												x	
Member 1B-2																		
Seminole		0	0	0	0	x			x	x								
McAlester		0	0	0	0	0	x											
Fitts	0	0	0	0	x	0	x		x				x	x				
Wapanucka	0	0	0	0					x									
Tishomingo	0	0	0	0														
Ardmore	0	0	0	0	x													
Member 2-3A																		
Seminole	x	0	0	0	0	0	0	x		0	0		0					
McAlester	0	0	0	0	0	0	x											
Fitts	0	0	0	0	0	0	x											
Wapanucka	0	0	0	0	0	0	x											
Tishomingo	0	0	0	0	0	0	x											
Ardmore	0	0	0	0	0	0	x											
Member 3A-3B																		
Seminole	x	0	0	0		x	x			x			x	x				
McAlester	0	0	0	0		x	x						x	x				
Fitts	0	0	0	0		x	x						x	x				
Wapanucka	0	0	0	0		x	x						x	x				
Tishomingo	0	0	0	0		x	x											
Ardmore	0	0	0	0		x	x											
Member 3B-4																		
Seminole	x	0	x	x	x	x	x		x	x			x					
McAlester	x	x	x	x	0	0	x		x	x								
Fitts	x	x	x	x	0	0	x		0	0								
Wapanucka	0	0			0	0	x											
Tishomingo	0	0																
Ardmore	0	0																

0-Major criteria

x-Minor criteria
(Members 1 and 3 each comprise 2 units)

F-Fernvale limestone

tational change occurred in the Arbuckle basin. Only by round-about traverse of several stratigraphic cross sections through several provinces could the Viola correlations be made between the Seminole and Ardmore areas.

Vertical lithologic differences.—If abrupt and non-repeating vertical lithologic changes occur between members having no lateral variations, the factors of vertical sample interval and horizontal well spacing would be of little importance. If the contact is gradational, as most member contacts in the Arbuckle basin are, the inter-member surface must be chosen at the confluence of the greatest number

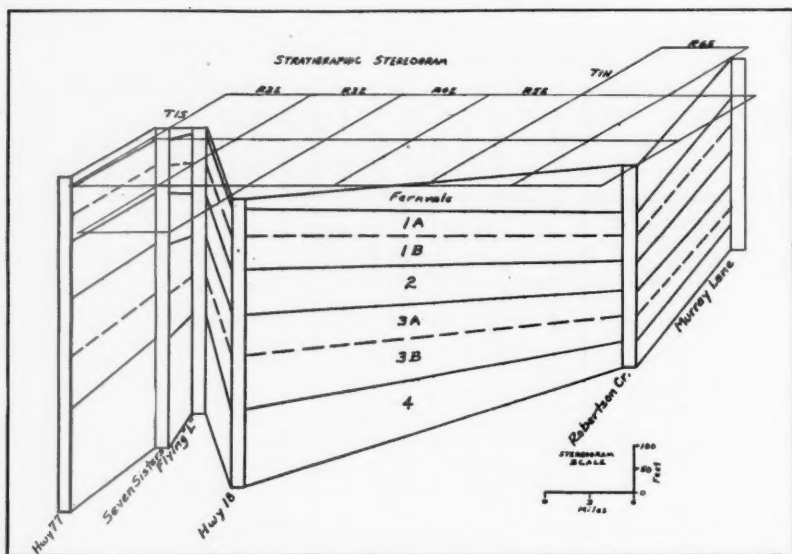


FIG. 11.—Stratigraphic stereogram (field sections).

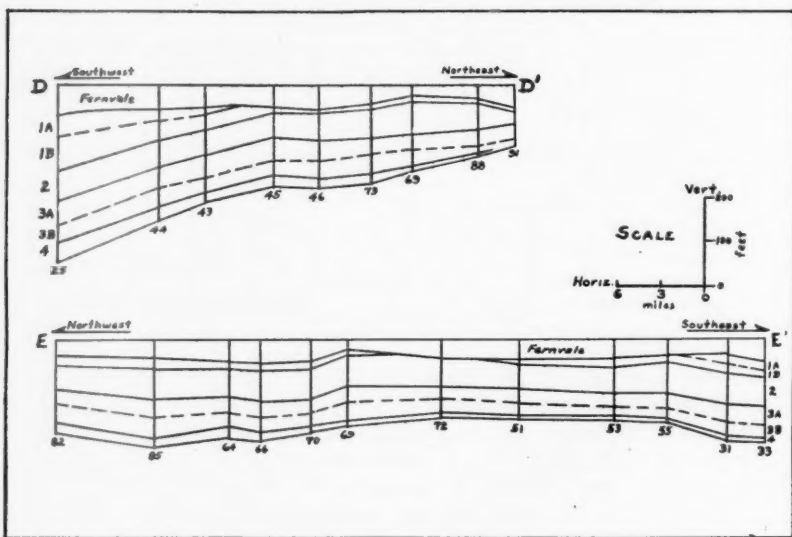


FIG. 12.—Stratigraphic cross sections DD' and EE'.

of changes, that is, texture, chert, fossils, indigenous clays, and insoluble residues. The initial controls for choosing the contacts in any single suite of cuttings are thus sample interval and abruptness of the lithologic change. The many observed minor changes, which correlated from test to test in the platform area, prove that the Viola members are composed of thinner correlatable lentils which could be mapped, if the density of drilled tests was greater. Choice of the major vertical lithologic changes determined the final subdivision of the Viola limestone into four members of regional extent. Members one and three have been further subdivided into units 1A and 1B, and units 3A and 3B. These members and sub-members are shown by thickness, in Table IV and Table V.

CRITERIA FOR SUBDIVISION

The generalized criteria for subdivision of the Viola limestones are shown in Table VI, which was constructed *after* all correlations were completed on the detailed lithologic cross sections. It is an assembly of the obvious lithologic reasons for placing the inter-member surfaces in the stratigraphic positions shown on the cross sections (Figs. 11-13). The criteria are arranged by provinces and member contacts to illustrate their relative value in subdividing and correlating the formation. Table VI also shows a division of criteria into major and minor value where several are used, but it does not show in which member, above or below the contact, the criteria were found which are responsible for the placement of the inter-member surface.

Following are the criteria, assembled from Table VI, listed in order of their importance. The numerals signify the number of times the listed criterion was a distinct aid in subdividing the Viola limestone in the detailed lithologic regional cross sections.

<i>Criteria</i>	<i>Major</i>	<i>Minor</i>
Chert percentage	22	7
Residue percentage	14	7
Texture of rock	12	11
Color of rock	9	10
<hr/>		
Silica content	7	9
Fossil abundance	5	18
Chert type	4	5
Sand content	3	11
Glauconite content	3	9
Silica clay content	3	3
Plastic clay content	0	8
Dolomite content	1	7
Tripoli development	1	3
Pyrite	1	2
Parallelism	0	9
Indigenous shale content	0	8
Pseudo-oölite distribution	0	7
Totals	85	134

Subdivision of the Viola limestone into four principal members in six provinces of the Arbuckle facies involved the choice of three major and two minor surfaces

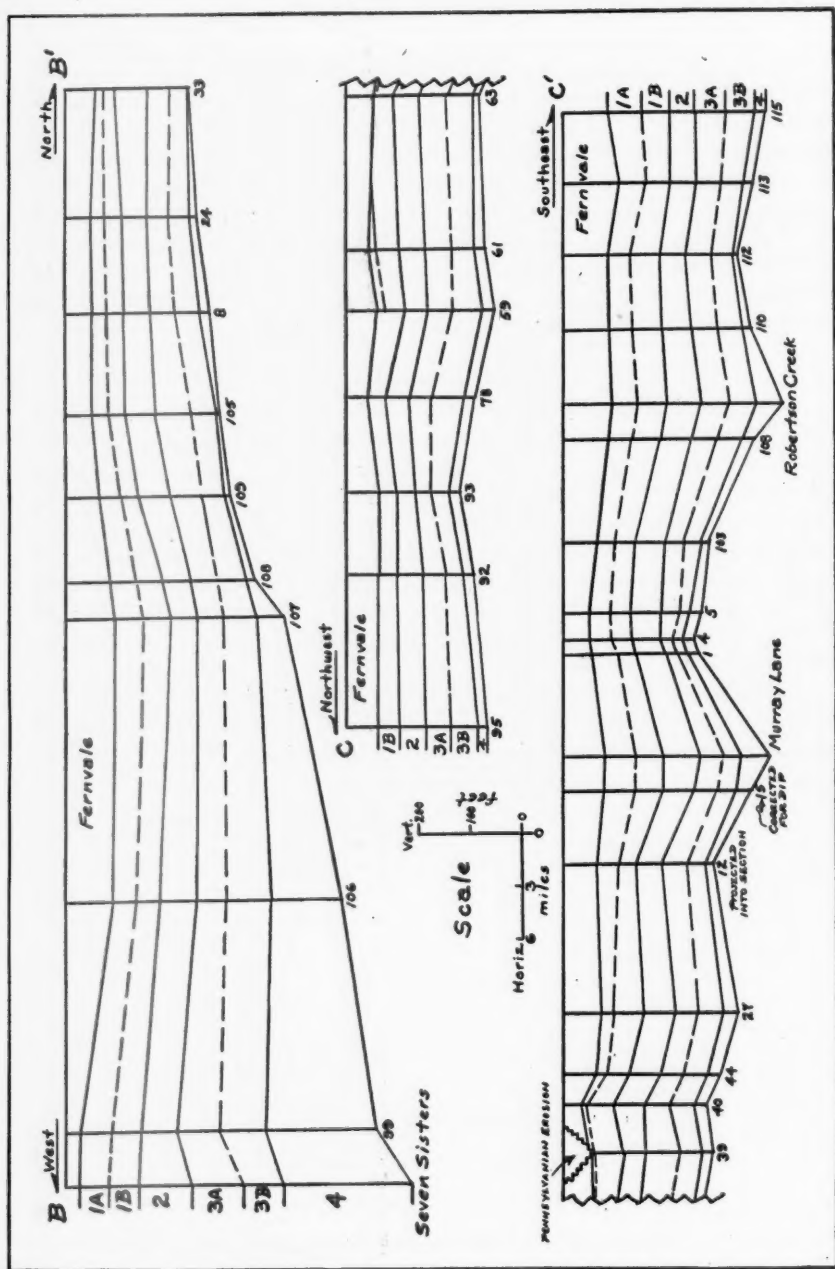


FIG. 13.—Stratigraphic cross sections BB' and CC'.

based on all available lithologic data. The foregoing listing indicates that four criteria are predominant in subdivision of the Viola limestone: (1) chert percentage, (2) residue percentage, (3) texture of rock, and (4) color of rock. Inasmuch as chert is the predominant constituent in insoluble residues, it appears that the Viola limestone can be subdivided into its members on the platform and platform slope of the Viola depositional basin in south-central Oklahoma without the use of insoluble residues, provided accurate estimates of chert are logged. Subdivision of the formation in the Wapanucka, Tishomingo, and Ardmore provinces, however, is difficult, regardless of the number of data available, because the diagenetic separation of Viola constituents is incomplete, or sedimentation was essentially continuous in those areas.

Table VI shows other interesting relations. Insoluble residues and chert percentages are of major value for all inter-member surfaces, but predominantly so for Members 1A-1B, 1B-2, 2-3A, and 3B-4 (Fig. 14). Texture is of minor value between units 1A-1B and 3A-3B, but of major value for choosing the contacts of Fernvale-1A, 1B-2, and 2-3A. The 2-3A inter-member surface is also easily chosen by noting pyrite, glauconite, and tripoli, which have major value on that contact. Those three constituents near any lithologic break are considered to be criteria for disconformity, and their concentration at the base of Member two is of major geologic importance in the genetic history of the Viola limestone. Fossils were more often used than realized during correlations, and they might have yielded much more correlative data, despite partial destruction by the drill, had they been rigidly classified as to type without generic and specific identifications. Sand was obviously of more value where abundant in Fernvale limestone and Member one. The surface between Members three and four was chosen on chert type, chert percentage, silica clay, and silica, which are more easily appraised in insoluble residues. The number of major criteria used is of course directly dependent on the number available and the following listing for that reason alone shows the surfaces in the order in which they are most easily recognized.

<i>Inter-Member Surface</i>	<i>Number of Times Major Criteria Were Used</i>
Member 2-3A	25
Fernvale 1A	19
Member 1B-2	13
Member 3B-4	12
Member 1A-1B	8
Member 3A-3B	8

This listing checks nicely with the relative ease of choice of inter-member and intra-member breaks during sample examination *without* the aid of regional correlation. Some vertical lithologic differences in the Viola are easily recognized, under the microscope. These include the surfaces between Fernvale limestone and Member 1A or 1B; 1B and 2; 2 and 3A; 3B and 4 in Fitts and Seminole provinces. Surfaces between units 1A and 1B, 3A and 3B are difficult to recognize in samples from those provinces. One exception in those provinces is the surface between

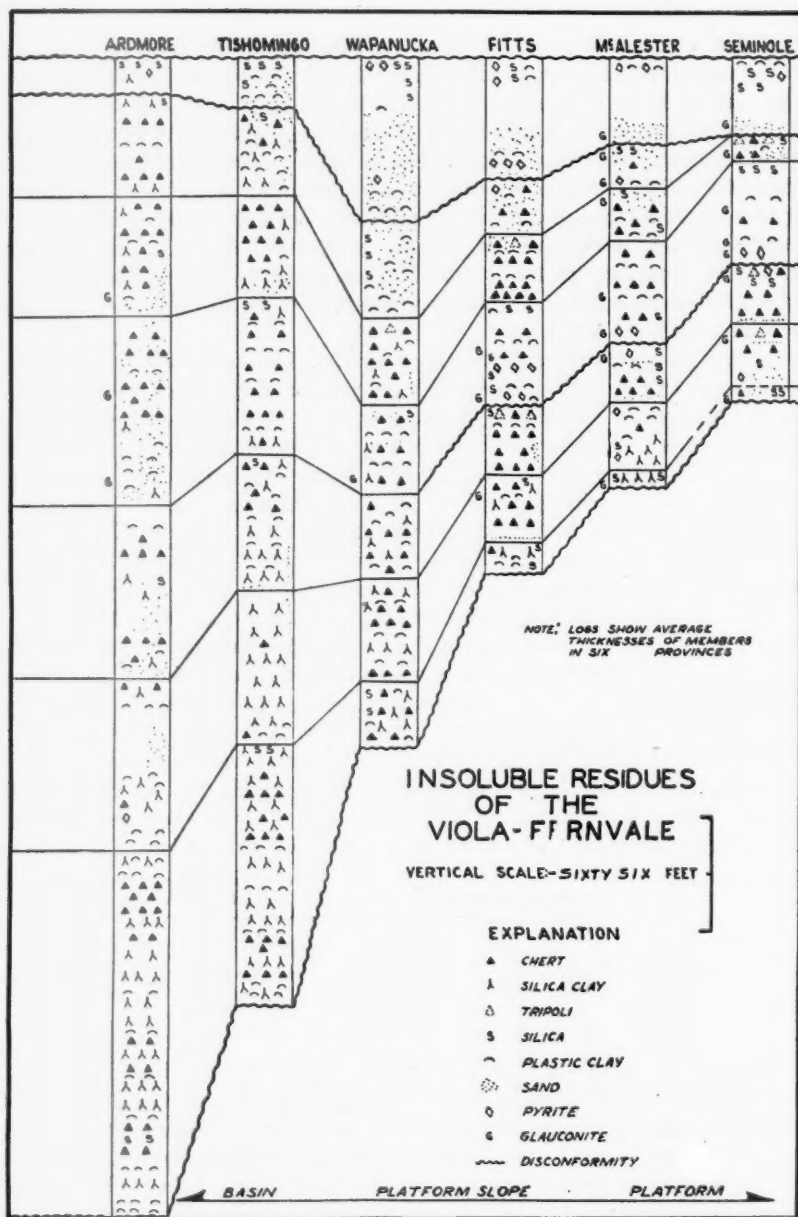


FIG. 14.—Insoluble residues of Viola and Fernvale limestones.

Fernvale limestone and Member one which is generally the most easily chosen of all surfaces because of textural differences. In Wapanucka province, however, it is difficult to choose the contact between the thick sandy Fernvale limestone and the underlying sandy Viola limestone.

The minor criteria are only minor in the sense that great reliance is not placed upon them in the particular localities and surfaces where better criteria are available. Indeed, many major criteria became minor criteria and *vice versa*, depending on the correlative lithologic data present on the lithologic cross sections. Glauconite, for example, has virtually no correlative value, except for the contact between Members 2 and 3 in Seminole, McAlester, and Fitts provinces (platform and platform slope facies).

DISTRIBUTION OF MEMBERS

The Fernvale limestone is thickest along a southeasterly trend from the Pauls Valley area through the southwest part of the Fitts province to the Wapanucka

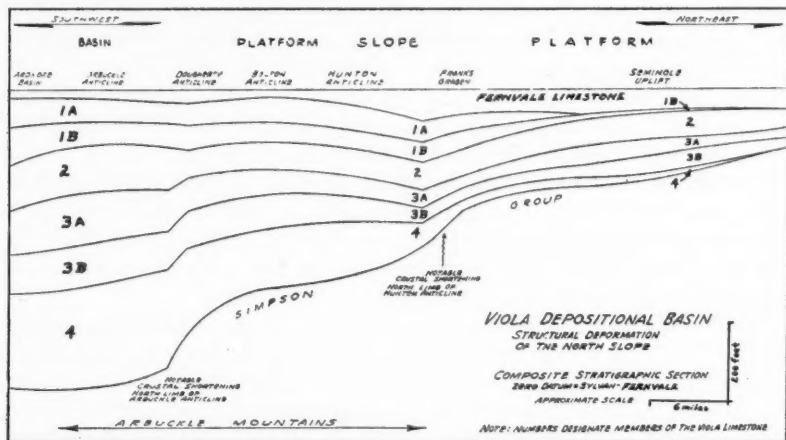


FIG. 15.—Viola depositional basin (north flank).

province (Fig. 7). All members of the Viola limestone, with a few local exceptions, show a general basinward thickening (Figs. 11-13).

Northeastward thinning of Member one is caused by loss of minor lentils (intra-member thinning), loss of the upper part of Member one (unit 1A), and overlap by the Fernvale limestone, which is separated everywhere from Viola members below by an erosional unconformity of regional extent in the Mid-Continent region. Member two is relatively constant in thickness northeast of the Arbuckle Mountains, but thickens southwestward within the Arbuckle geosyncline. Member three is abnormally thin in the Franks graben of the Fitts province, but in other areas shows the normal basinward thickening. Member four thickens basinward abruptly from the Fitts and Wapanucka provinces. Figure 15 shows the

average regional gradation in thickness of all members on the north flank of the Viola depositional basin. The average thickness of members in each province is shown in Table V.

All members are present in the greater part of the area of study. Members one and four disappear northeastward on the Seminole platform. Traces of the northeast edges of these members have been placed on the Fernvale-Viola isopach and chert maps to show the effect which member disappearance may have on total section thickness (Figs. 6 and 10). The structural map of the Fernvale-Viola section also depicts these traces for a check of the possible influence which ancient structural elements, reflected by the alignment of present structural trends, may have had upon the distribution of Viola sediments (Fig. 8).

UTILITY OF SUBDIVISIONS

The Fernvale and Viola limestones have not been productive in specific lentils or members in south-central Oklahoma. Had such been the case, however, the immediate economic advantage of carefully subdividing the section would be obvious. There are several less pressing theoretical and practical objectives in the subdivision as completed.

First, it was found that Viola dolomites almost invariably are porous and show oil stains. The possibility of locating these petroliferous lentils and localizing them both areally and stratigraphically, could have economic value.

Second, the areal localization of vast amounts of oil in the Viola and other limestones of Fitts field in the Franks graben were, early in the history of the field, considered to be related to sedimentary porosity; hence, a detailed lithologic knowledge of the Viola was considered important by commercial stratigraphers seeking new producing beds like that in Fitts field.

Third, the ability to predict within several tens of feet how thick an undrilled Viola section is in a wildcat test, which has penetrated the Fernvale limestone and at least 40 feet of the upper Viola limestone, is of economic significance in reaching the petroliferous Bromide and McLish limestones and sandstones on the platform slope and platform. Table III lists numerous bore holes which did not penetrate the Viola limestone completely because detailed lithologic and stratigraphic knowledge of the Viola was not available to the wildcatter.

Fourth, the economic significance of determining the origin of lithologic features of the Fernvale and Viola limestones should not be underestimated, for oil may yet be found near the northeast wedge-edge of a Viola limestone member with secondarily induced porosity where the member is overlapped by the much younger Fernvale limestone. Knowledge of the regional characteristics of the Viola limestone members may thus be of economic value.

Fifth, though it is not intended that the origin of the Fernvale and Viola constituents should be considered in this paper, an adequate subdivision of the section, which can readily be applied with the normal tools of the commercial stratigrapher and without insoluble residues, is necessary to an appraisal of

intra-member lithologic gradation which in turn aids in determining the pre-depositional travel and post-depositional modifications of Viola sediments.

Sixth, the value of subdivision is its very existence in the light of a prior worker; that it can be accomplished for the guidance of later workers who will have more tests available, even though the samples may be poorer, is important knowledge for those lithologists and stratigraphers interested in the origin and distribution of carbonate sediments.

ECONOMIC CONSIDERATIONS

PRODUCTIVE VIOLA WELLS (TABLE III)

- Magnolia's Craddock No. 1, SE., SE., SE., Sec. 24, T. 2 N., R. 6 E.
Production from 4,000 to 4,503 feet, in part of Sylvan shale, all of Fernvale and Viola limestones, and part of Bromide limestone (Fitts field)
- Delaney's Craddock "A" No. 1, NW., SE., NE., Sec. 25, T. 2 N., R. 6 E.
Production from 3,923 to 4,400 feet, in Fernvale, Viola, and Bromide limestones (Fitts field)
- Skelly's Akers No. 1, SE., SW., NE., Sec. 36, T. 2 N., R. 6 E.
Production from 4,048 to 4,393(?) feet in steeply dipping lower Fernvale and Viola limestones (Fitts field)
- Blackstock's Moody No. 5, NE., SW., SW., Sec. 23, T. 2 N., R. 7 E.
Production from 4,040 to 4,295(?) feet in lower Fernvale, Viola, and uppermost Bromide limestone (Fitts field)
- Amerada's Smith No. 1, SE., SW., NW., Sec. 28, T. 2 N., R. 7 E.
Production from 3,646 to 3,923(?) feet throughout Fernvale and Viola limestone section (Fitts field)
- Moore's Smith "A" No. 7, SW., NE., NW., Sec. 31, T. 2 N., R. 7 E.
Production from 3,654 to 3,945(?) feet throughout Fernvale and Viola section (Fitts field)
- Carter's Claytor No. 1, center, W. $\frac{1}{2}$, NE., SW., Sec. 27, T. 2 N., R. 9 E.
Production from 6,148 to 6,434 feet from top of Member two, Viola limestone, down to lower Bromide sandstone (wildcat—McAlester basin)
- Snyder-Lynch's Newby No. 1, SE., NE., NE., Sec. 24, T. 5 N., R. 4 E.
Production from 2,324 to 2,414 feet in lower part of Fernvale limestone and Member one (unit 1-B) to Member two in Viola limestone (wildcat between Seminole and Pauls Valley areas)
- Cities Service's Lamirand No. 1, NE., SE., SW., Sec. 27, T. 6 N., R. 2 E.
Production from 5,118 to 5,130 feet in lower part of Member three and top part of Member four where brown, fine to medium crystalline, oil-stained dolomite is interbedded with buff, finely crystalline limestone; Member four is very thin (wildcat north of the Pauls Valley area)
- Delaney's Bugher No. 1, SE., SE., SW., Sec. 12, T. 7 N., R. 2 W.
Production from 7,445 to 7,676 feet in lower part of Member two, Member three, and Member four, Viola limestone, and in McLish formation (wildcat 20 miles north of Pauls Valley area).

SUMMARY OF PRODUCTIVE TESTS STUDIED

Though this study includes only certain specific tests drilled before 1942, it is obvious that Viola production from naturally porous beds, undisturbed by fracturing, is negligible. The Franks graben, where oil is produced in major quantity from Viola limestone, is a highly faulted and fractured area in which the reservoirs are not related to lithologic variations of the Fernvale-Viola section, but to fracture systems which the limestones were competent to retain.

Of the productive Viola wells afore listed only the Cities Service's Lamirand No. 1 is a true lithologic reservoir which is caused by pores made available through the diagenesis of Viola sediments. Though many tests have penetrated porous Viola dolomite sections in the Seminole, McAlester, and Fitts provinces, and those same Viola sections contain some bituminous shales, the intercrystalline porosity in the dolomites is evidently not continuous; nor was it made available

at the proper moment to the bituminous oily shales during early diagenetic stages when oil, as it formed, could have moved into dolomite interstices.

The petroleum potential of the Viola limestone, in other than fractured areas or areas where secondary (post-lithification) porosity may have been induced during post-Viola pre-Fernvale time, or during Pennsylvanian erosion, is thus considered negligible, though small amounts of oil from this type of Viola reservoir will continue to be found as long as wells are drilled in south-central Oklahoma.

CONCLUSIONS

The Fernvale and Viola formations of south-central Oklahoma are composed primarily of limestone. The Viola limestone is composed of calcium carbonate, magnesium carbonate, silica in several forms, complex clays, and detrital quartz sand, with minor amounts of glauconite, pyrite, manganese, and limonite. Limestone is the predominant rock in the Viola formation, with the exception of the Seminole area where dolomites are quantitatively important. Chert is most abundantly concentrated on the platform slope between the comparatively chert-free Seminole platform and the siliceous limestones of the Arbuckle geosyncline. Chert is characteristically nodular where bedding surfaces are undulatory, and bedded where the enclosing limestones are planar-bedded.

Thickness of the Fernvale-Viola section ranges from 150 feet on the Seminole platform to 725 feet in that part of the Arbuckle geosyncline included in this study. The presence of thick Fernvale limestone in a broad trend coinciding with the Viola platform slope indicates that the epeirogenic unrest initiated in the Arbuckle geosyncline after Viola deposition shifted the axis of thickest Fernvale deposition northeastward from the northwest-trending axis of maximum Viola deposition.

The Viola limestone is divisible into four principal members which thicken southwestward from the platform to the basin. Overlying the Viola limestone unconformably is the coarsely crystalline crinoidal Fernvale limestone which shows locally anomalous thickening as a result of its deposition on eroded upper members of the Viola limestone. The Fernvale limestone transgresses the Viola limestone from the southwest in the basin where it lies on Member one, to the northeast on the platform where it lies on Member two. The Viola limestone also transgresses the Simpson group northeastward. In the basin, Viola limestone lies on Bromide limestone, in part of the platform slope and the platform it rests on the McLish formation, and, high on the platform, Viola dolomite lies on the Oil Creek formation.

The mass characteristics of Viola strata indicate that the Arbuckle facies in south-central Oklahoma is areally divisible into six stratigraphic provinces in which thickness, texture, color, silica content, and quartz sand content are essentially similar indicating somewhat equivalent source, conditions of deposition, and diagenetic history. These areal subdivisions are, however, gradational

and Viola sections in one province may be correlated with those in adjacent stratigraphic provinces. The test of this areal subdivision of the Viola limestone is the ease with which a new log may be assigned to its correct province without reference to the location of the test from which the samples were obtained.

Isopachous and lithologic data from the Fernvale and Viola limestones indicate that the orogenies which crumpled and faulted south-central Oklahoma had no effect on the original Viola basin of deposition in the Arbuckle geosyncline and on the Seminole platform. Regional uplift (epeirogeny), rather than local deformation, appears to have caused the northeastward wedging-out of Members one and four. The close correlation of this epeirogeny with effective wave base in the Viola seas is apparent both in the regional northeastward thinning and in the lithologic character of the Viola members.

The Fernvale and Viola limestones are potentially petroliferous where secondary porosity was formed near unconformities prior to the deposition of superjacent beds, and where the coincidence of fracturing and available oil from subjacent formations occurred subsequent to the lithification of Viola strata. The regional northeastward lithologic gradations from low-porosity limestone to porous dolomites on the Seminole platform are not considered economically significant in the exploration for great new Viola oil fields, although showings of oil have been found throughout many Viola sections in south-central Oklahoma.

SELECTED BIBLIOGRAPHY

- ALLEN, VICTOR T. (1936), "Terminology of Medium-Grained Sediments," *Nat. Res. Council Report of Committee on Sedimentation, 1935-36*, pp. 18-47.
- ANDREE, K. (1908), "Über Stäuge und Unterbrochene Neeres Sedimentation, ihre Ursachen, sowie über deren Bedeutung für die Stratigraphie," *Neues Jahrb. für Min., Beil. Band 25*, pp. 366-421.
- ARDMORE GEOLOGICAL SOCIETY (1946), "A Structural and Stratigraphic Consideration of the Arbuckle Mountains and the Criner Hills," *Field Trip Report*, pp. 1-20.
- ATHY, L. F. (1930), "Density, Porosity and Compaction of Sedimentary Rocks," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, pp. 1-24.
- (1930), "Compaction and Oil Migration," *ibid.*, Vol. 14, pp. 25-36.
- BARTON, JACKSON M. (1945), "Pre-Permian Axes of Maximum Deposition in West Texas," *ibid.*, Vol. 29, pp. 1336-48.
- BOYD, W. BAXTER (1938), "Jesse Pool, Pontotoc and Coal Counties, Oklahoma," *ibid.*, Vol. 22, pp. 1560-78.
- BURPEE, G. E., AND W. L. WILGUS (1935), "Insoluble Residue Methods and Their Application to Oil Exploitation Problems," *Min. and Met.*, Vol. 16, pp. 418-20.
- CLARK, STUART K., JAS. I. DANIELS, AND J. T. RICHARDS (1928), "Logging Rotary Wells from Drill Cuttings," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 22, pp. 59-76.
- CLAYPOOL, C. B., AND W. V. HOWARD (1928), "Method of Examining Calcareous Well Cuttings," *ibid.*, Vol. 12, pp. 1147-52.
- CLOUD, P. E., V. E. BARNES, AND JOSIAH BRIDGE (1945), "Stratigraphy of the Ellenburger Group in Central Texas—A Progress Report," *Univ. Texas Pub.* 4301, pp. 133-61.
- COLE, TAYLOR (1942), "Subsurface Study of Ellenburger Formation in West Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 26, pp. 1398-1409.
- COMMITTEE OF STRATIGRAPHIC NOMENCLATURE (1933), "Classification and Nomenclature of Rock Units," *ibid.*, Vol. 17, pp. 843-63.
- CONKLING, R. A. (1927), "Geology of Pontotoc County; Oil and Gas in Oklahoma," *Oklahoma Geol. Survey Bull.* 40-S, pp. 1-27.
- CRAM, IRA H. (1932), "Correlations of the Eastern Oklahoma Ordovician Section with That of the Arbuckle Region" (abstract), *Bull. Geol. Soc. America*, Vol. 43, p. 286.
- DECKER, C. E. (1930), "Simpson Group of the Arbuckle and Wichita Mountains, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, pp. 1493-1506.

- AND CLIFFORD A. MERRITT (1931), "The Stratigraphy and Physical Characteristics of the Simpson Group," *Oklahoma Geol. Survey Bull.* 55, pp. 1-112.
- (1933), "Viola Limestone, primarily of Arbuckle and Wichita Mountain Region, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 17, pp. 1405-35.
- (1936), "Some Tentative Correlations on the Basis of Graptolites of Oklahoma and Arkansas," *ibid.*, Vol. 20, pp. 301-11.
- (1936), "Table of Tentative Lower Paleozoic Correlations on the Basis of Graptolites," *ibid.*, Vol. 20, pp. 1252-57.
- (1941), "Simpson Group of Arbuckle and Wichita Mountains," *ibid.*, Vol. 25, pp. 650-67.
- DEFORD, RONALD K. (1944), "Rock Colors," *ibid.*, Vol. 28, pp. 128-37.
- (1946), "Grain Size in Carbonate Rock," *ibid.*, Vol. 30, pp. 1921-28.
- DOTT, ROBERT H. (1927), "Notes on Pennsylvanian Paleogeography with Special Reference to South-Central Oklahoma," *Oklahoma Geol. Survey Bull.* 40-J, pp. 1-22.
- (1933), "Overturned Beds in Arbuckle Mountains, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 17, pp. 865-68.
- (1934), "Overthrusting in Arbuckle Mountains, Oklahoma," *ibid.*, Vol. 18, pp. 567-602.
- (1941), "Regional Stratigraphy of Mid-Continent," *ibid.*, Vol. 25, pp. 1619-1705.
- EATON, J. E. (1929), "The By-Passing and Discontinuous Deposition of Sedimentary Materials," *ibid.*, Vol. 13, pp. 713-61.
- (1931), "Standards in Correlation," *ibid.*, Vol. 15, pp. 367-84.
- EDSON, FANNIE CARTER (1927), "Ordovician Correlations in Oklahoma," *ibid.*, Vol. 11, pp. 967-75.
- (1930), "Lower Paleozoic Unconformities," *ibid.*, Vol. 14, p. 947.
- (1935), "Resume of St. Peter Stratigraphy," *ibid.*, Vol. 19, pp. 1110-30.
- GOLDMAN, M. I. (1921), "Association of Glauconite with Unconformities" (abstract), *Bull. Geol. Soc. America*, Vol. 32, p. 25.
- GRIM, RALPH E. (1942), "Modern Concepts of Clay Materials," *Jour. Geol.*, Vol. 50, pp. 225-75.
- HATCH, RASTALL, AND BLACK (1938), *The Petrology of the Sedimentary Rocks* (3d ed.). 383 pages. George Allen and Unwin, Ltd., London.
- HEDBERG, HOLLISS D. (1926), "The Effect of Gravitational Compaction on the Structure of Sedimentary Rocks," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10, pp. 1035-72.
- (1936), "Gravitational Compaction of Clays and Shales," *Amer. Jour. Sci.* (5th Ser.), Vol. 31, pp. 241-87.
- HEISTAND, T. C. (1938), "Studies of Insoluble Residues from 'Mississippi Lime' of Central Kansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 22, pp. 1588-99.
- HENDRICKS, T. A., M. M. KNECHTEL, AND JOSIAH BRIDGE (1937), "Geology of Black Knob Ridge, Oklahoma," *ibid.*, Vol. 21, pp. 1-29.
- HOWARD, W. V., AND MAX W. DAVID (1936), "Development of Porosity in Limestones," *ibid.*, Vol. 20, pp. 1389-1412.
- HOWELL, J. V. (1931), "Silicified Shell Fragments as an Indication of Unconformity," *ibid.*, Vol. 15, pp. 1103-04.
- HYATT, DON L. (1936), "Preliminary Report on the Fitts Pool, Pontotoc County, Oklahoma," *ibid.*, Vol. 20, pp. 951-74.
- IRELAND, H. A. (1936), "Use of the Insoluble Residues for Correlation in Oklahoma," *ibid.*, Vol. 20, pp. 1086-1121.
- AND OTHERS (1947), "Terminology for Insoluble Residues," *ibid.*, Vol. 31, pp. 1479-90.
- KAY, G. MARSHALL (1945), "Paleogeographic and Palinspastic Maps," *ibid.*, Vol. 29, pp. 426-50.
- (1947), "Analysis of Stratigraphy," *ibid.*, Vol. 31, pp. 162-68.
- KRAUS, EDGAR (1924), "Logging Wells by the Rotary Methods," *ibid.*, Vol. 8, pp. 641-50.
- KRUMBEIN, W. C., AND F. J. PETTIJOHN (1938), *Manual of Sedimentary Petrography* (1st ed.). 549 pp. D. Appleton-Century Company, New York.
- (1939), "Graphic Presentation and Statistical Analysis of Sedimentary Data," *Recent Marine Sediments* (Amer. Assoc. Petrol. Geol.), pp. 558-91.
- (1942), "Criteria for Subsurface Recognition of Unconformities," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 26, pp. 36-52.
- (1942), "Physical and Chemical Changes in Sediments after Deposition," *Jour. Sed. Petrol. Geol.*, Vol. 12, pp. 111-17.
- (1945), "Recent Sedimentation and the Search for Petroleum," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 29, pp. 1233-61.
- KRUMBEIN, W. C., AND F. J. PETTIJOHN (1947), "Analysis of Sedimentation and Diagenesis," *ibid.*, Vol. 31, pp. 168-74.
- LANDES, KENNETH K. (1946), "Porosity through Dolomitization," *ibid.*, Vol. 30, pp. 305-18.
- LEHMAN, ROY P. (1945), "Thrust Faulting in Arbuckle Mountains, Oklahoma," *ibid.*, Vol. 29, pp. 187-209.
- LEVORSEN, A. I. (1928), "Geology of Seminole County; Oil and Gas in Oklahoma," *Oklahoma Geol. Survey Bull.* 40-BB, pp. 1-70.

- MCQUEEN, H. S. (1931), "Insoluble Residues as a Guide to Stratigraphic Studies," *Missouri Bur. Geol. and Mines 56th Bien. Rept.*, Appendix 1, pp. 1-32.
- MATHER, KIRKLEY F. (1918), "Superficial Dip of Marine Limestone Strata. A Factor in Petroleum Geology," *Econ. Geol.*, Vol. 13, pp. 198-206.
- MELTON, F. A. (1930), "Johnston and Murray Counties; Oil and Gas in Oklahoma," *Oklahoma Geol. Survey Bull.* 40-LL, pp. 1-24.
- MORGAN, GEORGE D. (1924), "Geology of the Stonewall Quadrangle, Oklahoma," *Oklahoma Bur. Geol. Bull.* 2. Also *Oklahoma Geol. Survey Bull.* 40, Vol. II (1930).
- OCKERMAN, J. W. (1931), "Insoluble Residues of the Hunton and Viola Limestones of Kansas," *Jour. Sed. Petrology*, Vol. 1, pp. 43-46.
- OTTO, GEORGE H. (1938), "The Sedimentation Unit and Its Use in Field Sampling," *Jour. Geol.*, Vol. 46, pp. 569-82.
- PATNODS, H. WHITMAN (1941), "Relation of Organic Matter to Color of Sedimentary Rock," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 25, pp. 1921-33.
- PAYNE, THOMAS G. (1942), "Stratigraphical Analysis and Environmental Reconstruction," *ibid.*, Vol. 26, pp. 1697-1770.
- PETTITJOHN, F. J. (1942), "Quantitative and Analytical Sedimentation," *Nat. Res. Council Report of Committee on Sedimentation, 1940-1941*, p. 43-61.
- RUEDEMANN, RUDOLPH, AND CHARLES E. DECKER (1934), "The Graptolites of the Viola Limestone," *Jour. Paleon.*, Vol. 8, pp. 303-27.
- SCHENCK, HEDBERG, TOMLINSON, EATON, AND WHITE (1941), "Stratigraphic Nomenclature," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 25, pp. 2105-2211.
- SINGEWALD, QUENTIN D., AND CHARLES H. REED (1935), "Insoluble Residues from Paleozoic Limestones of the Mosquito Range, Colorado," *Jour. Sed. Petrology*, Vol. 5, pp. 115-22.
- SLOSS, LAWRENCE L., AND RALPH H. HAMBLIN (1942), "Stratigraphy and Insoluble Residues of Madison Group (Mississippian) of Montana," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 26, pp. 305-35.
- TAFF, JOSEPH A. (1901), "Coalgate, Indian Territory," *U. S. Geol. Survey Geol. Atlas Folio 74*, pp. 1-6.
- (1902), "Atoka, Indian Territory," *ibid.*, Folio 79, pp. 1-8.
- (1903), "Tishomingo, Indian Territory," *ibid.*, Folio 98, pp. 1-8.
- (1928), "Preliminary Report on the Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma," *Oklahoma Geol. Survey Bull.* 12, pp. 1-95. Reprint of *U. S. Geol. Survey Prof. Paper 31* (1904).
- TARR, W. A. (1938), "Terminology of the Chemical Siliceous Sediments," *Nat. Res. Council Report of Committee on Sedimentation, 1937-1938*, pp. 8-27.
- THIEL, GEO. A. (1942), "Diagenetic Changes in Calcareous Sediments," *ibid.*, 1940-1941, pp. 81-110.
- TOMLINSON, C. W. (1928), "Oil and Gas Geology of Carter County; Oil and Gas in Oklahoma," *Oklahoma Geol. Survey Bull.* 40-Z, pp. 1-77.
- TRAGER, E. A. (1920), "A Laboratory Method for the Examination of Well Cuttings," *Econ. Geol.*, Vol. 15, pp. 170-76.
- TRASK, P. D. (1931), "Compaction of Sediments," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, pp. 271-76.
- TWENHOFEL, W. H. (1931), "Environment in Sedimentation and Stratigraphy," *Bull. Geol. Soc. America*, Vol. 42, pp. 407-24.
- (1937), "Terminology of the Fine-Grained Mechanical Sediments," *Nat. Res. Council Report of Committee on Sedimentation 1936-1937*, pp. 81-104.
- (1938), "Rate and Continuity of Deposition of Sediments," *Tulsa Geol. Soc. Digest*, pp. 9-10.
- AND S. A. TYLER (1941), *Methods of Study of Sediments* (1st ed.). 183 pp. McGraw-Hill Book Company, Inc., New York.
- (1942), "The Rate of Deposition of Sediments; A Major Factor Connected with Alteration of Sediments after Deposition," *Jour. Sed. Petrology*, Vol. 12, pp. 99-110.
- W. A. J. M. VAN WATERSCHOOT VAN DER GRACHT (1931), "The Permo-Carboniferous Orogeny in the South Central United States," *K. Akad. Wetensch. Amsterdam Verh.*, Deel. 27, No. 3, pp. 1-170.
- WELLMAN, DEAN C. (1937), "Insoluble Residues of Dundee and Detroit River (Upper Monroe) Formations of Central Michigan," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, pp. 317-32.
- WHITESIDE, ROBERT M. (1932), "Geologic Interpretation from Rotary Well Cuttings," *ibid.*, Vol. 16, pp. 653-74.
- WILMARTH, M. GRACE (1938), "Lexicon of Geologic Names of the United States," *U. S. Geol. Survey Bull.* 896, Pt. 1, pp. 1-1244; Pt. 2, pp. 1245-2396.
- WOOLNOUGH, W. G. (1937), "Sedimentation in Barred Basins, and Source Rocks of Oil," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, pp. 1101-57.
- (1942), "Geological Extrapolation and Pseud-Abyssal Sediments," *ibid.*, Vol. 26, pp. 765-92.

GEOLOGY AND EXPLORATION FOR OIL IN SALINAS VALLEY, CALIFORNIA¹

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ABSTRACT

The stratigraphy and structure of the basin are reviewed incorporating some of the recent cartographic refinements and including a detailed discussion of the King City fault, whose nature and location have been clarified by recent wildcat drilling. The writer believes that there were two important periods of faulting in the Salinas Valley and that the northern part of the basin can be divided into three important fault blocks—Southwest, Central, and Northeast. The King City fault line separates the Central and Northeast blocks and has had an important influence during Tertiary time, both on sedimentation and the development of structure.

The history of exploration for oil in the Salinas Valley is discussed in chronological order, culminating with the recent discovery of the San Ardo oil field by The Texas Company.

INTRODUCTION

The Salinas Valley basin is the fifth largest marine Tertiary sedimentary basin in California. It is in Monterey and San Luis Obispo counties and in the Southern Coast Range geomorphic province. Drained by the Salinas River which flows northwestward to Monterey Bay, it is a rich agricultural area and the scene of some interesting early California history. Unlike the larger basins, the alluvial-covered area is small, being confined to the Salinas and San Antonio river valleys. East of the Salinas River are low rolling hills, but on the west the relief is fairly rugged, reaching elevations as high as 5,000 feet. The geographic boundaries are the Sierra de Salinas Mountains and the Gabilan Range, both consisting of crystalline rocks, on the north and northwest; the Santa Lucia Range with its Franciscan and older rocks on the west and southwest; the granitic La Panza Mountains on the south; and the famous San Andreas rift on the northeast. The basin has two outlets, one through a narrow channel at the northwest end into the Santa Cruz basin and another narrow channel at the southeast end where it joins the Carrizo Plains (Fig. 1).

The Salinas Valley basin occupies a unique status in the history of California oil exploration in that the first oil field was not discovered until after 50 years of prospecting during which period ninety-four dry holes were drilled. The other Tertiary sedimentary basins—San Joaquin, Santa Maria, Ventura, and Los Angeles—became productive with the first wildcatting at the beginning of the

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twentieth century and each has produced more than a billion barrels of oil from their numerous fields.

STRATIGRAPHY

General.—A comparison of these five Tertiary basins reveals that sedimentation was nearly the same in all of them, particularly in the Miocene. The Salinas Valley basin is favorably comparable in length (approximately 100 miles) with the other basins, but is considerably narrower and shallower. Consequently the volume of sediments is much smaller. The limited width of the basin has contributed to rapid facies changes and great lithologic variation in short distances.

A detailed discussion of the stratigraphy is beyond the scope of this paper. However, it is briefly reviewed to incorporate recent refinements of cartographic and time-stratigraphic nomenclature.

For the purpose of the petroleum geologist, Cretaceous sedimentary rocks are treated as basement along with the Franciscan, Sur series metamorphic rocks, and Santa Lucia granodiorite. The Cretaceous sediments in the Salinas Valley are not believed to be either source or reservoir beds for oil. However, it is recognized by the writer that basement may, under favorable conditions, act as a reservoir rock for oil accumulation as in the Santa Maria, Edison, and other fields.

Between Cretaceous and Oligocene time there was a period of profound uplift accompanied by normal faulting of great magnitude followed by erosion. However a small area in the northwestern part of the valley in the Junipero Serra Quadrangle was beneath sea-level in the Eocene and received an accumulation of several thousand feet of sediments. By Oligocene time erosion had worn down most of the basement surface underlying the present site of the Salinas Valley to a southwest-dipping peneplaned surface, closely resembling its present configuration. Near the present location of the King City fault, there was a scarp high on the northeast side, somewhat dissected by streams which cut across it and emptied into the small Eocene embayment on the northwest. Probably talus covered the base of this scarp. This was the setting prior to the beginning of widespread and nearly continuous Tertiary deposition.

The post-Eocene formations are discussed in ascending order.

Berry formation.—This formation represents the first sediments to be deposited on the old peneplaned and southwest-dipping basement. Defined by R. R. Thorup (7)³, its type locality is near the Berry Ranch in T. 20 S., R. 6 E. Here it is composed of 1,100 feet of conglomeratic continental sediments with redbeds in the upper part. It rests disconformably on Eocene at its type locality. Sediments of similar lithologic characteristics and position in the section rest on the basement in other parts of the Salinas Valley and have been called Berry by other workers. It is known to grade laterally into the Vaqueros marine sands. The writer's idea is that the Berry varies in age from Oligocene to middle Miocene and possibly

³ Numbers in parentheses indicate references at end of paper.

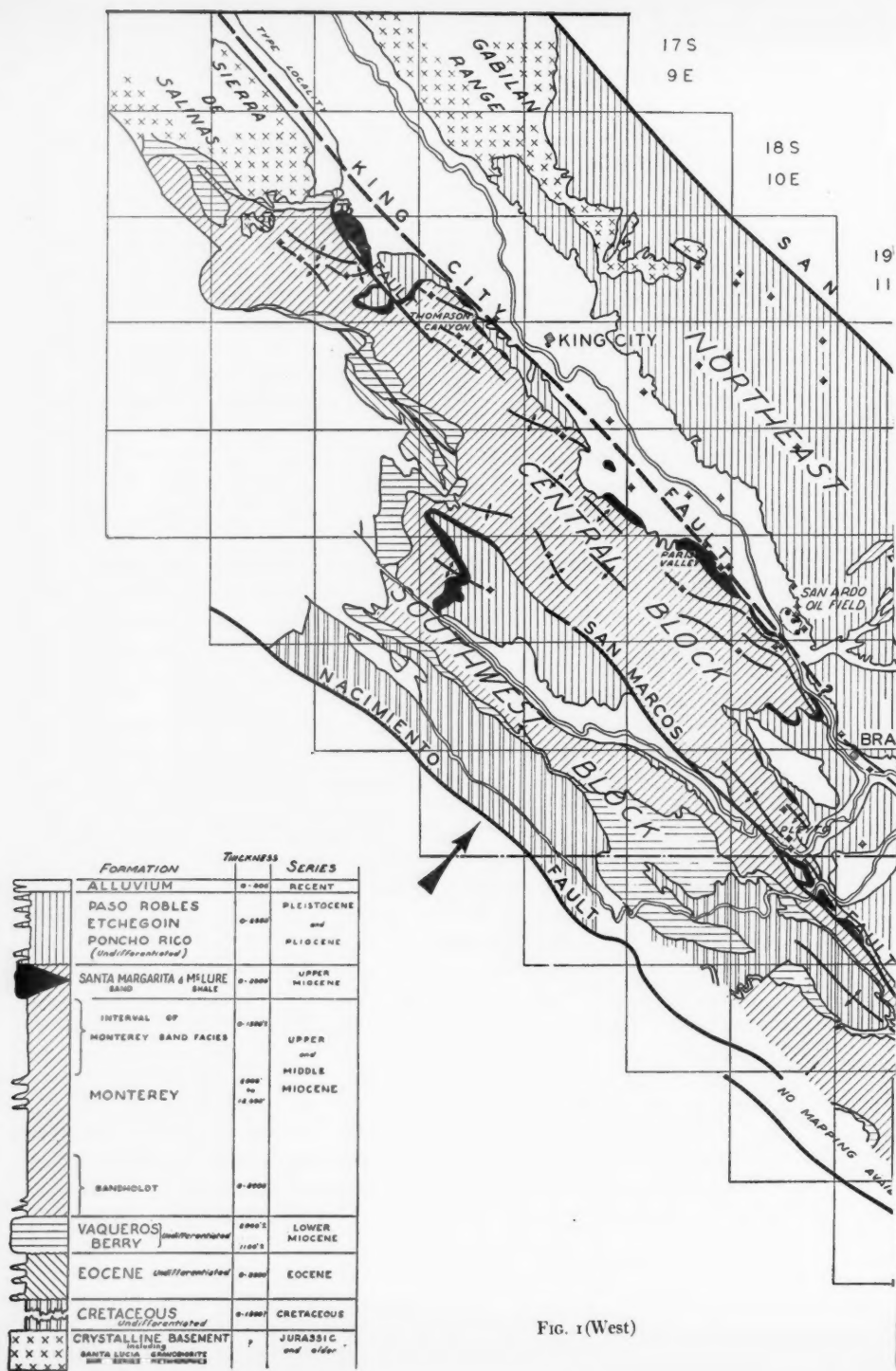


FIG. 1(West)

19
11

FIG. 1 (East)

higher, and is the continental equivalent of several marine formations. There is some question whether it should be employed as a formational term. Lithologic characteristics and position in the section suggest that the Berry, in some areas, is equivalent to the Sespe and Lospe formations and to the Walker formation of the San Joaquin Valley. No oil showings are known. It contains some permeable sands in the outcrop although it is not in a favorable position to receive oil from source beds.

Vaqueros formation.—The Vaqueros was first named by H. H. Hamlin (8) and later redefined by R. R. Thorup (7). The type section is on Vaqueros Creek and consists of 2,000 feet of marine sandstone with some interbedded siltstone. It contains the *Turritella inezana* megafossil assemblage. Microfauna in the siltstones indicates a Zemorrian age for most of the formation although the upper 500 feet in the type section is considered lower Saucesian. In this area and in some other areas along the west side of the Salinas Valley the Vaqueros rests conformably on the Berry. However, in other areas it rests directly on Cretaceous or crystalline rocks. The Vaqueros is confined to the Southwest and Central fault blocks (Fig. 1) in the northern part of the valley, but may be present on the Northeast fault block in the vicinity of Paso Robles where the geologic relations are obscured by recent sediments and there is not much well control. The writer believes that in general it is overlapped on the Central block by younger beds before reaching the King City fault. Lithologically similar sands on the northwest and southeast margins of the basin contain a Temblor megafauna and rest on Berry redbeds. Surface work and subsurface information from wildcat wells show that the lower Miocene seas transgressed from west to east so that the Vaqueros sand undoubtedly rises in the section eastward. However, there is no definite proof that these Temblor sands are the same or continuous with the Vaqueros.

Although no oil is known in Vaqueros outcrops, a deep well of the Shell Oil Company, Inc., in the Pleyto area encountered high-gravity oil, but could not be made to produce because of lack of permeability in the sand. Most of the other wells drilled to the Vaqueros found it tight and barren.

Sandholdt formation.—This name has been proposed by R. R. Thorup (7) for 950 feet of clay shale between the Vaqueros sand and the Monterey cherty shales in the same area as the type sections of the Vaqueros and Berry. It is confined to the Southwest and Northeast blocks. Maximum thickness of 2,000 feet has been recorded by M. N. Bramlette (5) in Horse Canyon along Arroyo Seco Creek. In the Paraiso Springs and Highland homocline areas the Sandholdt overlies the Temblor sands; contains a Luisian fauna in the former and a Relizian fauna in the latter area. Like the Berry, the Sandholdt's formational status is questionable as it is strictly a lithologic term and appears to become younger in general toward the east, changing from lower Miocene to middle Miocene (Saucesian to Relizian to Luisian). In some outcrop localities and in some wells Monterey shale rests directly on Vaqueros, further suggesting that the Sandholdt grades laterally into

both Monterey and Vaqueros. Oil has been noted in sandy silt stringers in several wildcat wells, but the formation in general is too tight to produce.

Monterey formation(11).—Also known as the Salinas shales, this formation consists of cherty and porcellaneous shales in the lower part and diatomaceous shales and silts in the upper part. It is very extensive on the Southwest and Central fault blocks and its uppermost members transgressed onto the Northeast block. The Monterey sea transgressed the older Vaqueros on the east and developed sandy facies as it approached the old King City fault scarp. On the Northeast block the Monterey is much thinner and grades eastward into sand. Its maximum thickness is 12,000 feet in the deepest part of the basin and the average thickness is 4,000 feet. The great thickness of these shales is attributed to downwarping of the Central and Southwest blocks and continued movement along the King City fault. Although it is primarily upper Miocene at its type locality, in other areas it ranges down into the middle and possibly the upper part of the lower Miocene. Its age varies from Saucian to Delmontian and in deeper parts of the basin it comprises the entire Miocene section. This formation is believed to be the source of most of the oil seepages, showings, and oil produced in the Salinas Valley. In many places it contains tar in fractures along the outcrop, and outcropping sand stringers in its upper part are saturated with tarry oil in the Paris Valley and Thompson Canyon areas. Many wildcat wells have encountered oil in fractures in the Monterey.

Monterey sands.—These sands are not well developed in the outcrop section but are better known from recent wildcat wells of The Texas Company along the east side of the Central fault block on the west side of the Salinas River from King City to Bradley. They range in age from upper middle Miocene to upper Miocene and may be equivalent in part to Santa Margarita sands in the eastern and southern parts of the basin. These sands are fine- to coarse-grained, poorly sorted, arkosic, and interbedded with Monterey-type shales and silts. They grade westward into Monterey shale. Maximum thickness is approximately 1,500 feet. Permeability is fair. The sands are overlain by Monterey diatomaceous silts which are overlain by Santa Margarita fossiliferous sands. The Monterey sands apparently buttress out to a great extent against the King City fault scarp as they are developed only to a limited extent on the Northeast block. Oil showings have been cored in these sands in several wells and the producing sand in the newly discovered San Ardo field is believed to be one of these sands.

Santa Margarita sand.—This formation was defined by H. W. Fairbanks (9) near the town of the same name at the south end of the Salinas Valley. It consists of marine, well sorted and arkosic sand in general. It overlies Monterey shales in a greater part of the valley, unconformably near the edges of the basin and conformably in the central part. Its age is upper Miocene (Neroly stage of Clark; Delmontian and a part of Mohnian stages of Klempell). Like all other formations in the valley, the Santa Margarita varies in age. It becomes younger

toward the northwest and older toward the east where it replaces Monterey shale. The Santa Margarita can not be mapped continuously from locality to locality and the correlations are based on fossils and lithologic characteristics. It is probably not continuous and consists of separate, lenticular sand bodies. Logs of wildcat wells indicate that the Santa Margarita is divided into several sand bodies and interfingers with the Monterey. East of the Salinas River, in the Cholame Hills, the Santa Margarita reaches the maximum thickness of 2,500 feet, much of which is undoubtedly a sandy phase of older Monterey shales on the west. The Santa Margarita contains tar in the outcrop in the Paris Valley (San Ardo), Thompson Canyon, and the Mylar quarry along San Lorenzo Creek. Many old wells near these tar-sand exposures encountered tar at depth, but could not be made to produce. The Santa Margarita is permeable in both outcrop and well sections.

McLure formation.—This formation consists of siliceous and diatomaceous shales, mudstones, and silts with locally interbedded sands. Its maximum thickness is 700 feet. It overlies the Santa Margarita sand on the Northeast block, to which it is confined in its outcrop. It is regarded by N. L. Taliaferro and M. N. Bramlette as equivalent to the McLure shale of the Reef Ridge area in the San Joaquin Valley. There is some evidence that it is equivalent to the siltstone above the producing sand in the San Ardo oil field and, if so, is equivalent to the uppermost part of the Monterey. On the northeast, beds of similar lithologic character, named Poncho Rico by R. D. Reed (10), overlie B. L. Clark's King City formation which contains a Pliocene megafossil assemblage equivalent to the basal part of Arnold and Anderson's Jacalitos formation of the San Joaquin Valley. This indicates that the upper Miocene seas transgressed the basement on the northwest into Pliocene time without any marked hiatus in deposition or change in type of sedimentation. Conflicting and duplicating names have been used for the upper Miocene and Pliocene formations in the Salinas Valley and there is need for more information and a clarification of nomenclature.

The King City formation is not discussed here as a separate unit because of its limited extent and thickness. For convenience it is included in the uppermost part of the Santa Margarita formation.

Poncho Rico formation.—Defined by R. D. Reed (10), this formation consists of sands, silts, shales, and conglomerates and contains a good Pliocene megafossil assemblage. The writer desires to use the term Poncho Rico instead of Etchegoin because the type section of the former is in the Salinas Valley and the type section of the latter is in the San Joaquin Valley. Its relation to the Santa Margarita sand on the Central fault block is both conformable and unconformable. In some places the exact position of the contact is difficult to determine because of diatomaceous silt stringers in both formations. It is generally less than 500 feet thick on this block, but reaches the maximum thickness of 900 feet in the Cholame Hills where it is unconformable with the underlying McLure shale. There is a tar sand at the base of the Poncho Rico on the west bank of the San Antonio

River in the Pleyto area. Several old wells downdip from this outcrop encountered tar sand in this part of the section, but not in sufficient quantity to be produced. The sand members of the Poncho Rico have been found to be permeable in most wells drilled through it.

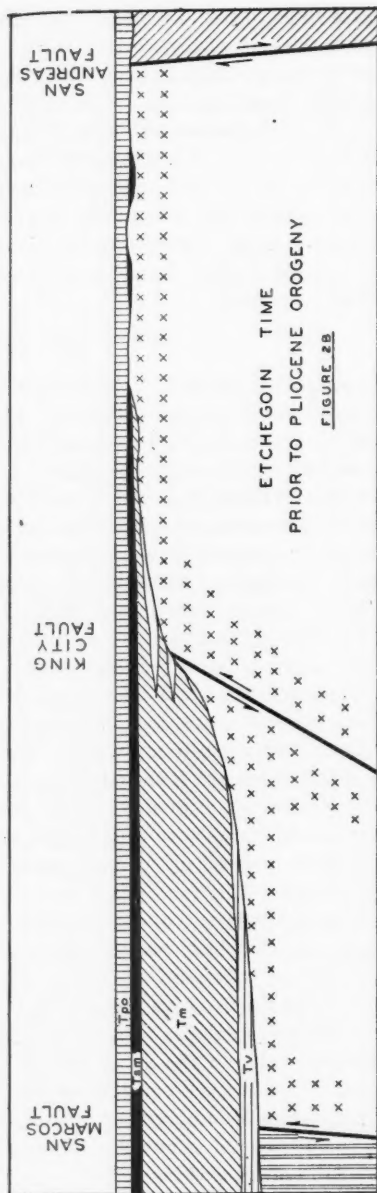
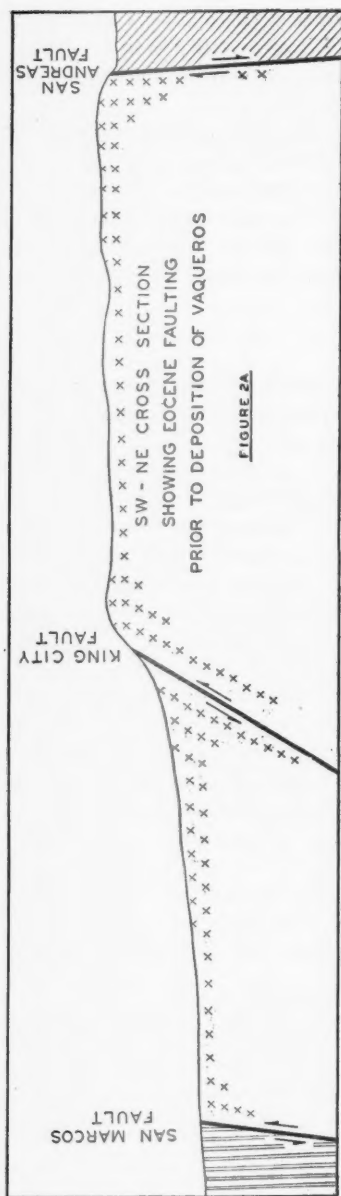
Paso Robles formation.—This formation is continental in origin, consisting of conglomerates composed of white, Monterey shale pebbles, and intercalated buff, gritty clays, and silts. It is conformable with the Poncho Rico in the areas of thickest deposition, but transgresses over the older formations with marked angularity in many areas. It is lithologically correlative with the Tulare formation of the San Joaquin Valley. No oil showings have been reported. It is late Pliocene and Pleistocene in age.

STRUCTURE

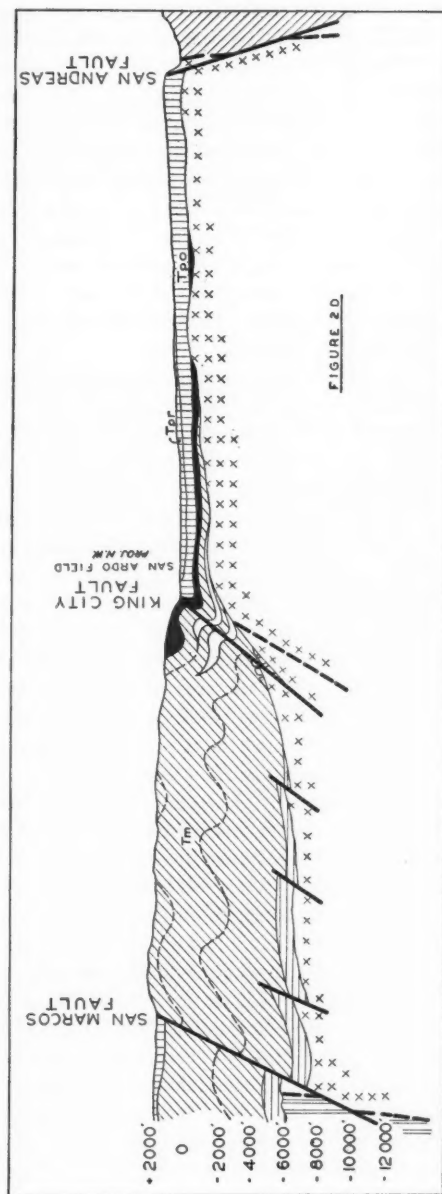
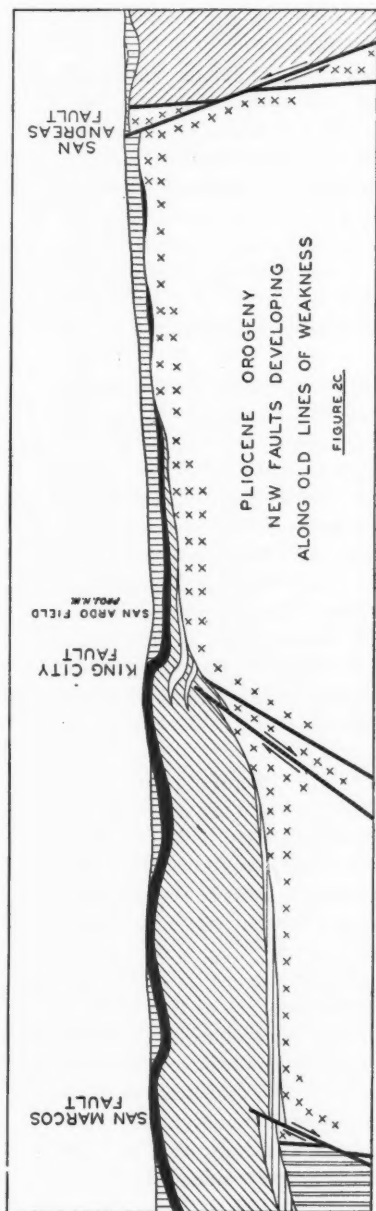
The structural features of the Salinas Valley, like the adjacent San Joaquin Valley and most of southern California, trend northwest and southeast.

Fault-block concept (Figure 1).—To the writer, one of the most important structural features for the petroleum geologist is the division of the basin into the three main fault blocks in Eocene time. These fault blocks had a marked influence both on the later structural developments and on Tertiary sedimentation. One, here named the Southwest block, lies between the Nacimiento and San Marcos faults; the second, the Central block, lies between the San Marcos and the King City faults, under the San Antonio Hills; the third, the Northeast block, lies between the King City and the San Andreas faults. All three of these basement blocks are in R. D. Reed's Salina province and in N. L. Taliaferro's Gabilan Mesa. The Southwest block basement has a Cretaceous cover in its central part with Sur series metamorphics and Santa Lucia granodiorite on the north end and granodiorite on the south end where it is exposed in the La Panza Range. The Central block basement is entirely Sur series and Santa Lucia granodiorite, and the Northeast block is predominantly Santa Lucia granodiorite. The Central and Northeast blocks were separated by a scarp, upthrown on the northeast side, which the writer believes was caused by faulting and has designated it the King City fault. This fault scarp had an especial influence on sedimentation throughout the Miocene and into the Pliocene. The limits of the Southwest block are somewhat hazy because of a series of faults and along what has been called the Nacimiento fault.

Structural history.—After the profound Eocene faulting (Figs. 2-A and 2-B), there was little orogenic disturbance until late Miocene. This is evidenced by the unconformity between the Santa Margarita and Monterey along the edges of the basin. There is some evidence of repeated normal faulting along the King City fault during Monterey time as it is difficult to think of a fault scarp, high enough to buttress out as much as 5,000 feet of Miocene section in the King City and San Ardo areas, existing before the beginning of Tertiary deposition and yet not contributing any noticeable amount of coarse detritus to the Monterey seas



FIGS. 2A-2B.—Vertical double-line pattern at extreme left indicates Cretaceous. Diagonal pattern at extreme right indicates Jurassic Franciscan.



Figs. 2C-2D.—Vertical double-line pattern at extreme left indicates Cretaceous. Diagonal pattern at extreme right indicates Jurassic Franciscan.
 FIG. 2D.—Present structure after mid-Pleistocene orogeny. Monterey sands shown in white.

in these localities. Rather, it suggests a gradual lowering of the Central block with respect to the Northeast block during Miocene time.

The next important event in the structural history of the Salinas Valley was the late Pliocene orogeny (Fig. 2-C) which resulted in general uplift, strong, folding, and development of thrust faulting along the line and in the opposite direction of the old Eocene normal faults—the San Marcos, King City, and San Andreas. This faulting had a strong horizontal component in addition to vertical movement, possibly because the compressional forces were not applied at right angles to the trend of the earlier faulting. Again in mid-Pleistocene time (Fig. 2-D), a similar orogeny accentuated the previously developed folds, some of which overturned and broke into thrust faults. Still later, movement of the rift type took place along the San Andreas and, the writer believes, to some extent along the King City faults.

The present structural picture shows the Southwest and Central blocks strongly folded in a northwest-southeast trend with the folds on the east side of the Central block intersecting the King City fault line. In contrast, the Northeast block is very gently folded, and in a large area is hardly more than a southwest tilted homocline. The folds on the Central block have no system of asymmetry and do not extend into the Northeast fault block. This suggests that the Northeast fault block with its high granitic basement and veneer of sediments was too rigid to fold and acted as a buffer against which the Central block was compressed. These conditions are the best evidence for shearing and lateral movement along the King City fault during the Pliocene and Pleistocene orogenies. The writer believes that this faulting was most pronounced in the basement rocks and did not reach the surface everywhere. Movement along the San Marcos fault uplifted the Southwest block considerably more than the Central block, exposing likely petroliferous beds in much of its area.

Early concepts of King City fault.—In outlining his conception of the structural development of the Salinas Valley, the writer has made use of recent well information which has led him to believe that the King City faults, ancestral and present, have been important factors in the structural evolution of this province. This theory was evolved from recent information, with the background provided by older treatises on Coast Range geology, and for that reason the writer would like to review some of the earlier concepts of the King City fault.

The King City fault was first mentioned in published record by B. L. Clark (3) who described it at the base of the steep northeast scarp of the Sierra de Salinas. He projected the fault southeast under the alluvium following the course of the Salinas River to the town of San Ardo whence it was believed to extend obliquely to its intersection with the San Andreas fault. This fault was one of the many that Clark hypothesized in his fault-block theory of the origin of present structural features in the Coast ranges. Another fault was designated by Clark along the southwest side of the Gabilan Range on the opposite side of the Salinas

River from the King City fault. This fault was called the Salinas fault and extended southeast along Peachtree Valley and likewise intersected the San Andreas fault. The area between the King City fault and the Salinas fault was considered a graben. The main theme of Clark's theory was that all folding during Tertiary time was due to drag caused by movement along basement faults.

R. D. Reed (2) disagreed with Clark's theory and pointed out several places in the Coast ranges where folding was entirely unrelated to faulting. Reed claimed that Clark's theory was not applicable to the Coast ranges as a whole, especially where Tertiary sediments are underlain by a Franciscan basement, but that the King City area, underlain by granitic rocks, might be one of the places where Clark's theory did hold true.

N. L. Taliaferro (1) described the King City fault as the northeast scarp of the Sierra de Salinas with a wide alluvial apron hiding the actual surface trace. He cited the probability that the Reliz fault, a high-angled thrust dipping southwest into the range, is a branch of the King City fault. This fault emerges from beneath the alluvial apron and dies out south of Reliz Canyon in Miocene sediments. He made note of a zone of steep dips and overturning along the west side of the Salinas River to San Ardo which may be a continuation of the King City fault although there is no actual surface evidence of faulting. He concluded that this faulting is recent, but that the King City fault is not a major feature of Coast Range structure.

M. N. Bramlette (5), in his discussion of the King City fault, mentioned the same steep and overturned dips with no visible evidence of displacement. He also described the difficulty of correlating wells on either side of its inferred location and the probable termination of thick marine Miocene deposits against a rising scarp on the east. He believed that the faulting was recurrent and that there was considerable horizontal movement.

Conclusions concerning King City fault.—All of these workers are in agreement that the King City fault can not be mapped on the surface, but that the zone of steep and overturned dips along a line from King City to San Ardo west of the Salinas River is suggestive of faulting. Along this zone, Paso Robles and older beds on the west are in contact with recent alluvial and terrace deposits. It is the writer's opinion that the fault is primarily a subsurface feature, but that the surface trace is probably obscured by alluvial and terrace deposits in front of the belt of steep dips, although R.R. Thorup⁴ believes that there is a good exposure of the King City fault on the Ansberry Ranch in the Paris Valley area. The topography between the belt of steep dips and the Salinas River is suggestive of faulting. There are numerous occurrences of offset stream drainage, and isolated lakes and depressions are common. The nearest exposures of older beds east of the Salinas River have very gentle dips. Several recent wells east of the surmised location of the fault in both the King City and San Ardo areas have encountered basement

⁴ Oral communication.

at very shallow depths. In contrast, a recent well of the Chanslor-Canfield Midway Oil Company, in Sec. 6, T. 23 S., R. 10 E., on the Central block about 2 miles west of the belt of overturned dips, encountered 8,000 feet of Monterey cherty shales on 170 feet or more of granodiorite breccia. This breccia is believed to be a recemented talus deposit at the base of the old scarp. The age of the talus is pre-Monterey and probably pre-Vaqueros. Other old wells close to the King City fault are reported to have encountered a thick section of homogeneous, granitic, basement detritus overlying and grading into the basement.



FIG. 3.—Paris Valley. Steeply dipping Santa Margarita reef beds in foreground southwest of King City fault and flat Poncho Rico beds in distance on Northeast block. Actual trace of King City fault is believed to lie at intersection of slope of hill in foreground with flat alluvial deposits under cultivation. (Photo by courtesy John H. Fackler.)

In conclusion, the writer believes that the King City fault system is a definitely established feature extending from the Sierra de Salinas to Bradley along the west side of the Salinas River. Southeast of Bradley there is no evidence for its continuation in the same form. The writer desires to repeat his opinion that there were two periods of faulting along the King City line: the first, in Eocene time, created the scarp which underwent periodic rejuvenation in Miocene time; the second, in Pliocene and Pleistocene time, was of a thrust nature in the opposite direction, with some lateral movement in contrast to the early normal faulting and located along the same trend, but not exactly coincidental with it. Facies changes and the early Eocene faulting along the King City line created a zone of

weakness that facilitated the movement of the later fault along the same line when the compressive forces from the southwest began.

HISTORY OF EXPLORATION

The first search for oil in the Salinas Valley began several years before the end of the nineteenth century and, as in the other basins, the first wells were downdip from oil seepages. The first well was drilled in the Paris Valley, near the town of San Ardo. During the period from 1900 to 1920, 19 wells were drilled in the vicinity of outcropping tar sands in the Pleyto and San Ardo areas. Some of these wells encountered tar and heavy oil showings, but no oil was produced with the exception of the Pleyto Oil Company's well No. 2, in the SE $\frac{1}{4}$ of Sec. 26, T. 24 S., R. 10 E. This well reached the depth of 3,215 feet in the Monterey shale and actually produced a small amount of heavy crude. Today the well is uncapped and oozes heavy oil which runs over the near-by road in the summer months.

The first activity by a major oil company was prior to 1914 by Standard Oil Company, centering in T. 19 S., R. 10 E., in the Peachtree Valley area near outcropping tar sands. Three wildcats were drilled in Secs. 19 and 28. These wells encountered some tarry oil showings, but no oil was produced.

In 1921 the Shell Oil Company, Inc., leased the San Miguel dome structure in the southwest part of T. 24 S., R. 12 E., and the north part of T. 25 S., R. 12 E., and drilled a test well on the axis, a little north of the surface apex, to the total depth of 4,665 feet in sands below the Monterey shale without encountering any oil showings worth testing.

Another important wildcat in 1925, the Jones Oil Company's Harriman No. 1, in Sec. 21, T. 19 S., R. 6 E., stopped in the Sandholdt formation, at the total depth of 4,608 feet. It is reported to have flowed 26° gravity oil for a short time. This well was on one of a series of tight, closely spaced folds in the Monterey shale.

During the late twenties and thirties, promising surface anticlines were leased, drilled, and found barren. This was the first important drilling activity in the Salinas Valley; more than 100,000 acres were leased. Failure of these tests was discouraging and most of the companies left the area.

The Shell Oil Company, Inc., continued exploration in the valley and in 1935 drilled on the Sulphur Canyon anticline in Sec. 34, T. 24 S., R. 10 E. This well is still the deepest in the valley; it encountered basement near its total depth at 8,994 feet. High-gravity oil showings were encountered in hard, tight Vaqueros sandstone, but no oil was produced. A second well on the same structure was low and barren.

In 1937 The Texas Company entered the Salinas Valley. Wildcats and core-holes on the north end of the basin were not successful. A lull followed from 1940 to 1945 when The Texas Company leased a large area from King City to Bradley on the west side of the Salinas River and near the King City fault. The objec-

tive was the Monterey sands which The Texas Company's geologists thought would be found well developed along this belt. Eight wildcats were on structures along this trend. The Monterey sands were found to be well developed and permeable. Oil showings were found in the two Aurignac wells in Sec. 4, T. 23 S., R. 10 E., which led to the drilling of a joint test by the North American Consolidated Oil Company, the Jergins Oil Company, and The Texas Company in Sec. 35, T. 22 S., R. 10 E. This well logged 30 feet of well saturated, heavy oil sand from 2,188 to 2,218 feet, but could not produce. These showings lead to the drilling of The Texas Company's Lombardi No. 1, in Sec. 27, T. 22 S., R. 10 E. This well logged good oil sand from 2,133 to 2,158 feet and was completed on November 5, 1947, as the discovery well in the Salinas Valley, pumping 84 barrels per day of 10° gravity clean oil. Subsequent completion of two more wells has proved 200 acres. Although there is some question, the writer thinks that the age of the producing Monterey sand is upper Miocene. The overlying diatomaceous silt contains a non-diagnostic microfauna which some paleontologists think is Pliocene. The producing sand is 300 feet thick, and rests on granite basement. Approximately the upper 25 feet is productive. The trap is believed to be a gently folded anticline on the Northeast block, nearly a mile northeast of the King City fault.

This discovery, although small, will undoubtedly stimulate wildcat drilling in the Salinas Valley during the next few years; much land north and east of the discovery well has already been leased.

REFERENCES

1. TALIAFERRO, N. L., "Geologic History and Structure of the Central Coast Ranges of California," in "Geologic Formations and Economic Development of the Oil and Gas Fields of California. Pt. 2. Geology of California and the Occurrence of Oil and Gas," *California Div. Mines Bull.* 118 (1940), pp. 119-63.
2. REED, R. D., *Geology of California*, Amer. Assoc. Petrol. Geol. (1933), pp. 43, 44, 52, and 262.
3. CLARK, B. L., "Tectonics of the Valle Grande of California," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 13, No. 3 (March, 1929), pp. 199-238.
4. ———, "Tectonics of the Coast Ranges of Middle California," *Bull. Geol. Soc. America*, Vol. 41, No. 4 (1930), pp. 747-828.
5. BRAMLETTE, M. N., AND DAVIESS, S. N., *U. S. Geol. Survey Prelim. Map 24*, Oil and Gas Inves. Ser. (1944).
6. ENGLISH, W. A., "Geology and Oil Prospects of the Salinas Valley—Parkfield Area, California," *U. S. Geol. Survey Bull.* 691-H (1918), pp. 219-50.
7. THORUP, R. R., "Type Locality of the Vaqueros Formation," in "Geologic Formations and Economic Development of the Oil and Gas Fields of California. Pt. 3. Descriptions of Individual Oil and Gas Fields," *California Div. Mines Bull.* 118 (1940), pp. 463-66.
8. HAMLIN, HOMER, "Water Resources of the Salinas Valley, California," *U. S. Geol. Survey Water-Supply and Irrigation Paper 89* (1904).
9. FAIRBANKS, H. W., "San Luis, California," *U. S. Geol. Survey Geol. Atlas Folio 101* (1904).
10. REED, R. D., "The Post-Monterey Disturbance in the Salinas Valley, California," *Jour. Geol.*, Vol. 33 (1925), pp. 591, 606.
11. HANNA, G. D., "The Monterey Shale of California at Its Type Locality with a Summary of Its Fauna and Flora," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 10 (October, 1928), pp. 969-85.

ACTIVE-SURFACE CATALYSTS IN FORMATION OF PETROLEUM¹

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ABSTRACT

It is suggested that explanations of the composition of petroleum and the method of their formation must be consistent with the limiting physical conditions shown by a study of producing fields and geological conditions. Of these conditions, relatively low temperatures, usually not exceeding 140°F., are most significant. There is a complete gap in our knowledge, particularly about chemical changes, between the contemporary sediments and the organic matter contained in them, and the heavy asphaltic and naphthenic petroleum which probably are petroleum in an early transition stage. Both geological and chemical evidence is in agreement and consistent with a relatively very low-temperature history for all petroleum.

The conclusions of D. C. Barton from a study of Gulf Coast oils published in 1934 that heavy asphaltic naphthenic oils, containing little or no gasoline, change with age and depth to lighter oils containing more light constituents and less heavy residue, are extremely important in view of this low-temperature history. The data on which Barton based his conclusions have been re-examined to include oils produced from newer fields and the trend of the changes noted by Barton has been confirmed and is discussed in a later paper. The variations in composition, however, for oils of the same age and depth are considerable. The conditions bringing about such changes are considered to be primarily the catalytic effects of the minerals in the formations with which the crude oil has been in contact, together with the relatively low temperatures for varying geologic ages. These conditions would require considerable variation from a simple linear function of age and depth since there is a wide variation in the catalytic effect of different minerals in producing chemical changes. Differences in the temperature gradients or bottom-hole temperatures also probably account for some of the variations in composition of oils of the same age and similar depth in different fields. Active surface minerals include most clays and sands containing clay, but such catalytic action has been noted with minerals other than clay. It is believed that the purer limestones and dolomites have little or no such catalytic action and that oils undergo substantially no change after migrating into such reservoir rocks. This is believed to be the explanation of many cases in which heavy oils containing little or no light constituents are found in limestone reservoirs, although of relatively great age and at depths greater than overlying formations containing younger but lighter oils.

The chemical complexity of petroleum is also best explained by the catalytic effect of active-surface minerals. The absence of olefins and the presence of aromatics is also indicative of such catalytic action. As measured by the polymerization of unsaturated hydrocarbons, such catalytic activity of active-surface minerals is not at all limited to clays of the type of fuller's earth, but is common, although variable, in many sedimentary rocks, including sandstone and shales.

In this discussion only facts bearing upon the major thesis are included. In recent years much information about the chemical composition of petroleum and much geological knowledge have been accumulated which throw light on the conditions of petroleum formation and its subsequent history. Geology reveals the limiting framework of physical conditions with which the chemical history must be consistent. Chemical theories continue to be proposed which have not taken into account the limiting conditions thus imposed. Present knowledge, both geological and chemical, furnishes evidence for conclusions which heretofore would have been merely unsupported speculation.

GENERAL FUNDAMENTAL CONDITIONS

Geology, in the broad sense, reveals the conditions of time, temperatures and pressures, the original and present environment, and probable nature of the origi-

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nal source material from which petroleums have been derived. These need not be reviewed here, except as certain facts bear upon the present suggestions.

Temperature history.—Geological evidence and direct observations of bottom-hole temperatures and oil-field temperature gradients is in good agreement with the evidence furnished by the chemical composition of petroleums, to the effect that these temperatures, from the time of the original deposition of the original source beds throughout their history to the present time, have been within the range from approximately 80°F. to 250°F. In most cases the maximum temperature has probably not exceeded about 140°F. (18, p. 269).

Original organic source material.—There has been much speculation about the nature of the original organic source material of petroleums. It is of interest in the present discussion, mainly in connection with the difficulty of accounting for the aromatic hydrocarbons in petroleums. The three general types of fossil organic material found in large quantities in formations of widely varying geological age, coal, the kerogen of oil shales, and petroleums, including natural gas, have evidently been derived from different types of original organic source material. This is certainly true for coal as compared with the other two and is probably true for kerogen and petroleum. It is generally believed that cellulose, lignin, and resins have been the original organic source material of coals, but such substances are not found in marine sediments in any significant proportions. There are intermediate types of formations such as the cannel coals and torbanites and the products of the destructive distillation of oil shales and of coals, by the so-called low-temperature processes, which are generally similar qualitatively, and include mainly saturated and unsaturated hydrocarbons, some aromatic hydrocarbons together with nitrogen bases, ammonia, phenols, organic acids, and organic sulphur compounds (26). Heavy petroleum oils also contain small proportions of complex substances which on decomposition, as in commercial cracking processes, yield very small amounts of phenols, naphthenic and fatty acids, nitrogen bases, and sulphur compounds, but in proportions much smaller than in shale oil and low-temperature coal distillates.

The original organic source material of kerogen and petroleum must have been organic debris either essentially different in kind, or difference in environment resulted in different final products. The very fine-grained oil shales were certainly deep-water deposits. The organic material in both must have been deposited under anaerobic conditions as required by recent bacteriological researches, the finding of chlorophyll porphyrins (29) in both oil shales and petroleums, and other considerations.

The original oil source beds are generally believed to have been shales and some were highly fossiliferous limestones. However, most typical oil shales contain no oil as such but commonly yield 30-40 gallons of oil and a few yield 100 gallons or more per ton, on destructive distillation. Typical oil shales are found to contain so-called kerogen, without evidence of oil formation, which are of ex-

treme geologic age, for example, the New Brunswick oil shale which Ells (8) has stated to be Upper Cambrian in age. The extensive black shales of Ohio, New York, and Michigan are Devonian. In other words, the kerogen of oil shales has persisted, without evidence of oil formation, under the same general conditions of temperature and pressure as oil-bearing formations from periods as remote as the Cambrian, or for periods of time as long as 400 million years. The fact that kerogen is highly insoluble in all organic solvents indicates that it is a highly polymerized material, and this fact, together with the proportions of products other than hydrocarbons obtained by destructive distillation, indicates that it is not essentially hydrocarbon.

Some oil shales contain small proportions of extractable oil. However, the common occurrences of oil shale devoid of oil, and of great geological age, indicate that petroleum is not formed from kerogen. The nature of the original source material of both kerogen and petroleum awaits further chemical investigation of the nature of kerogen, and chemical investigation of petroleum in transition stages. Very little light on either question is furnished by the investigations of Trask (28) on the organic matter contained in contemporary marine muds and sediments. Several hundred contemporary sediments examined by Trask showed no oil and the organic matter present contained a substantial proportion of combined oxygen, which is in agreement with earlier conclusions. There is a complete gap in the chemical history of petroleum between the contemporary sediments and bituminous material which has become changed sufficiently to be fluid and accumulate in the form of heavy petroleum or so-called asphalts or tars.

Evidence of low-temperature history. Chemical evidence.—This has been reviewed by the writer in two earlier articles (4). It need only be pointed out here that crude petroleum contains thermo-labile complex substances which are decomposed during ordinary distillation to give simpler sulphur compounds, naphthenic acids, and nitrogen bases. Very small proportions of such compounds may usually be extracted from the crudes but much larger proportions can be isolated after distillation. Thus, Pyhälä (19) found twelve times as much naphthenic acids in the distillate from a Russian crude as could be separated from the undistilled oil. Bailey (1) and his associates made similar observations regarding the nitrogen bases which could be extracted from the distillates of certain California oils.³ Kewley (16) noted that certain crudes contained complex sulphur compounds which were decomposed rapidly at about 150°C. to give hydrogen sulphide and mercaptans. The presence of chlorophyll porphyrins in many petroleum, and in oil shales, is also clear proof of a relatively low-temperature history (29).

³ Probably because nitrogen bases from certain California crudes have been more thoroughly investigated than those from other crudes, chemists have sometimes overlooked the presence of nitrogen bases in petroleum or other distillates in general. This has been reviewed by A. N. Sachanen in *Chemical Constituents of Petroleum*. The writer has separated pyridine-like bases from cracked gasoline from Oklahoma oils and also observed in the coking of a heavy Mexican oil that the uncondensed gases were heavily charged with ammonia.

Geological and field evidence.—The relatively low temperatures prevailing in oil-field formations is better known and understood by geologists than by chemists. McCoy and Keyte (18, p. 269) state:

Most of the known oil fields surely were formed under temperatures lower than 140°F. and Barton (2a) states:

The geologic history of the Gulf Coast is relatively simple. It is quite impossible that the Gulf Coast crude oils which are now [1934] being produced have been subjected to a temperature as high as 100°C. Some of the crude oil from the deeper sands may have been subjected to temperatures as high, but not much higher, than 70°C. Much of the crude oil cannot have been subjected to temperatures much higher than 50°C.—the normal average crude oil is indigenous to the formation in which it is found and has not migrated up from greater depth.

Since the date of Barton's publication, deeper drilling in the Gulf Coast fields shows bottom-hole temperatures at 12,000–15,000 feet as high as 135°C.

Since the composition of seven crudes has been thoroughly investigated by the United States Bureau of Standards, their depths, bottom-hole temperatures, producing formations and approximate ages are shown in Table I.

TABLE I
GEOLOGICAL AND FIELD DATA FOR SELECTED CRUDES

Field, Source of Crude	Producing Sand	Series	Average Depth (Feet)	Bottom-Hole Temp. (°F.)	Estimated Age (in Million Years)*
Ponca, Okla.	"Wilcox"	Middle Ordovician	3,872	139	360–380
East Tex.	Woodbine	Cretaceous	3,300	146	60–80
Bradford, Pa.	Bradford	Devonian (Chemung)	2,000	72	300
Greendale, Mich.	?	Middle Devonian	5,300	96	300
Winkler, Tex.	Big Lime	Permian	3,000	85	200–230
Midway, Cal.		Pliocene	2,050	115	10–13
Conroe, Tex.	Cockfield	Eocene	4,900	172	40–50

* Based on estimates by W. D. Urry and others from the study of radioactive minerals in pegmatite intrusions.

The highest temperature is that of the Conroe field where at 4,900 feet the temperature is 172°F. In the Permian basin of West Texas at 5,900 feet below sea-level the temperature is 126°F. In the East Texas field at 3,300 feet below sea-level the producing Woodbine sand has a temperature of approximately 146°F. Temperature gradients in various oil fields vary from 50 to 100 feet for each degree Fahrenheit increase in temperature (14). The present observed bottom-hole temperatures probably represent the maximum temperature of the formation for its entire geological history except where much of the insulating blanket of sedimentary strata has been removed by erosion and the present depth is much less than formerly.

The physical facts and the chemical evidence about low-temperature history are in full accord but the field observations enable us to fix the temperature range with greater accuracy than could be attained from the chemical evidence.

EVIDENCE THAT PETROLEUMS CHANGE IN COMPOSITION

It has long been recognized that in general the geologically older oils are lighter, more paraffinic, and contain more of the lighter oils such as gasoline and kerosene, than the more recent oils which are generally more naphthenic, contain little or no paraffin wax, little or no gasoline and kerosene, and much heavy residual oil and asphalt. The gravity and paraffinicity of crude oils are not strictly proportional to their age. The depth, temperature and, as suggested in the present paper, the character of the formation with which the oil has been in contact, are also factors. There are numerous apparent exceptions and these must be carefully considered. It is also well established that petroleum may be considerably modified in composition by selective adsorption of the heavier oils, asphalt, and certain constituents by migration through sands.

The studies made by D. C. Barton (2, 2a) of the relations between the composition of Gulf Coast crudes and their age and depth are important as showing considerable consistency in the trend to lighter, more paraffinic oils, with increasing age and depth. It is particularly significant that with oils of the same geologic age, the deeper oils are lighter. Barton's findings are shown by the accompanying graphs (Figs. 1) plotted from the United States Bureau of Mines analyses. His examination shows that petroleum does change in composition even at the low temperatures observed in these fields and that time is also a factor in producing such changes. It should be mentioned that the regularities noted by Barton for the Gulf Coast area have not been observed in certain other localities, but there are very plausible explanations for many of the apparent exceptions. In the Rocky Mountain area, which is much folded, faulted, and metamorphosed, Dobbin (7, p. 473) states that not all the oils in this area show the regularities of quality noted in the Gulf Coast oils. Certain very light oils are plainly the result of adsorption during migration. Dobbin states that these (Rocky Mountain) oils bear no demonstrable relation to the dynamic metamorphism which the region has undergone and notes (7, p. 473),

It is evident, therefore, that in addition to metamorphism, there are other factors responsible for the quality of the oil, such as differences in origin, weathering, natural *processes of refining or filtration*. . . .⁴

It is not clear whether Dobbin had in mind only the changes resulting from migration or other chemical changes. His observation, however, is very significant in the light of the suggestion made in the present paper about the role of catalytic active-surface minerals in contact with the oil in producing such changes. Other exceptional oils will be noted in later discussions.

STABILITY OF HYDROCARBON OILS

It has been calculated from the velocity constants of cracking (23) that at 212°F. the higher paraffins have a greater stability, with reference to temperature

⁴ Italics by present writer.

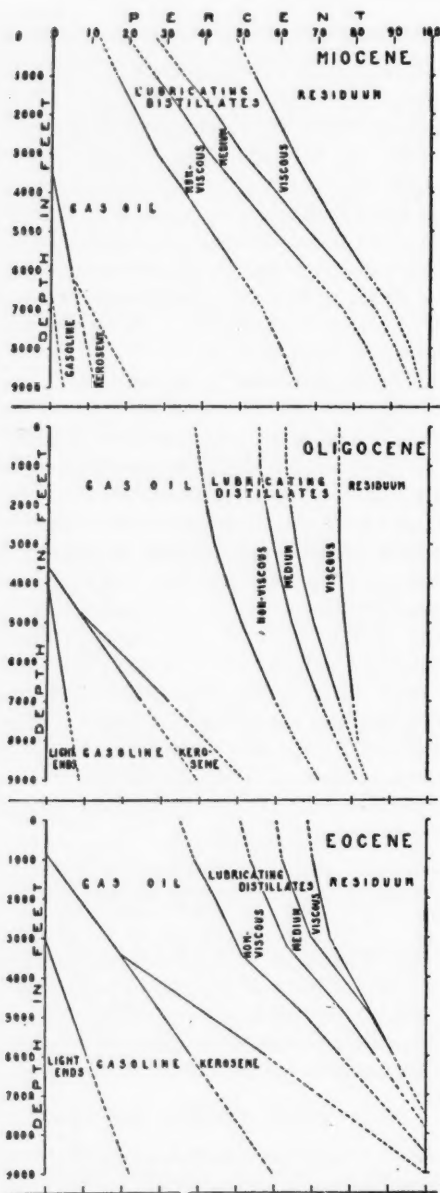


FIG. 1.—Composition of Gulf Coast oils, plotted graphically, by D. C. Barton, *Problems of Petroleum Geology* (1934), p. 125.

alone, than the element potassium, and according to these calculations the paraffins would remain substantially unchanged if maintained at 300°F., from the Middle Ordovician to the present. This is consistent with other observations, for example, massive ozocerite occurrences containing little or no oil.

If such calculations mean anything some factor other than the observed low-temperature range in oil formations must be found in order to account for the apparent fact that oils do change in composition, with age and depth.

It is also significant that, from general theoretical principles, the action of heat and pressure alone, if sufficient to produce changes in composition, should yield heavier or denser crudes from lighter ones, which is contrary to what is generally observed (31).

CATALYTIC ACTION OF ACTIVE-SURFACE MINERALS IN PETROLEUM FORMATION AND CHANGE

There is, altogether, considerable evidence that active-surface minerals, including clays (11), are catalysts which are effective, at the low-temperature ranges prevailing in oil-producing strata, in causing changes in composition and also probably in the early conversion of the original organic source material, first into heavy bituminous matter and this gradually into typical petroleum. Such catalytic action of clays or other active-surface minerals would explain the observations of Barton on Gulf Coast oils, previously described.

Active-surface minerals vary considerably in their catalytic activity on hydrocarbons, as known from the extensive work recently done on catalytic cracking with the aid of various catalysts. Good cracking catalysts are also generally good polymerizing catalysts for olefins at lower temperatures. That certain types of clays such as fuller's earth have a catalytic action in polymerizing unsaturated hydrocarbons has long been known, but this catalytic action is much more common among clays, natural shales, and minerals than has hitherto been appreciated. In an earlier paper by the writer (4, p. 625), the polymerizing activity of sedimentary rocks from Oklahoma, including various shales and sandstones, and certain minerals, was reported (Table II).

It may be noted in Table II that the six typical sandstones tested show a catalytic activity as indicated by polymerization, averaging more than half the catalytic activity of typical fuller's earth, and that three Oklahoma clays showed activity very nearly as high as typical fuller's earth. Even bauxite, which can have only a very small percentage of clay as an impurity, shows approximately two-thirds the polymerizing activity of fuller's earth. It is indicated by these results that catalytic activity is not limited to acid clays, but is due to active surfaces which strongly adsorb the hydrocarbons. Pure alumina and carbon, in active-surface forms, are capable of polymerizing unsaturated hydrocarbons (13).

Clays such as fuller's earth are capable of polymerizing isobutene at temperatures as low as -100°C . and, in general, the lower the temperature, the higher the molecular weight of the polymers formed. 2-Butene is 85 per cent polymerized

by fuller's earth on standing at room temperature for 4 months, and propylene is slowly polymerized under the same conditions, under pressure. It is true that the catalytic action of such active-surface materials is much decreased by moisture, which is also strongly adsorbed.

The results obtained by Gayer (12) in a study of the action of fuller's earth and other catalysts on propylene at 350°C., which is well below common cracking temperatures, are very nearly an experimental demonstration of the effects of such a catalyst in the formation of petroleum. In addition to propylene polymers

TABLE II
POLYMERIZING EFFECT OF OKLAHOMA SEDIMENTARY ROCKS AND
SOME MINERALS ON TURPENTINE

<i>Mineral</i>	<i>Per Cent Polymer</i>
Fuller's earth of Georgia	75
Sylvan shale	76
Red-bed clay	65
Tertiary clays	68
Greensand, New Jersey	72
Greensand, Texas	70
Serpentine, Easton, Pa.	60
Gray Persian sandstone	56
Stanley shale	57
Regan sandstone	50
Calvin sandstone	46
Simpson sandstone	34
Permian sandstone	30
Bentonite	34
Bauxite, Georgia	58
Silica gel	23
Kaolin	12
"Glaucosil" (acid leached greensand)	45
Prehnite (zeolite)	None
Stilbite (zeolite)	None
Talc	None
Infusorial earth	None
Powdered pumice	None
Ferric oxide, pure	None
Aluminum oxide, pure	None

there were also formed isoparaffins and olefins, including those of C₅, C₆, C₇, C₈, C₉, and higher hydrocarbons (32). A synthetic aluminum silicate had approximately the same catalytic activity as fuller's earth and a catalyst made up of 1 per cent alumina on silica had twenty times the activity of the best activated fuller's earth.

These results show that paraffins are formed from olefins, that isomerization and splitting of the hydrocarbon molecules takes place very rapidly at temperatures substantially below cracking temperatures, in fact, high temperatures alone do not produce the same results noted in this catalytic conversion of propylene. Here we note much the same so-called "hydrocarbon dispersion" that is found in the composition of typical petroleum. This action of fuller's earth and

other active-surface catalysts proves that many of the changes with which we are concerned in accounting for the complexity of petroleum do take place rapidly in the presence of such catalysts at temperatures which, in the absence of catalysts the hydrocarbons are relatively stable, and that the reactions are in some respects different from those resulting from the action of heat alone. The formation of some of the products in the resulting mixture can best be explained in the same way that the numerous products of the alkylation of isoparaffins by olefins are explained.

It is true that the complicated reactions which take place in low-temperature alkylation processes occur through the action of reagents such as concentrated sulphuric acid, hydrofluoric acid, and aluminum chloride. Such processes include isomerization, the splitting of hydrocarbons and the synthesis of new ones, molecular re-arrangements, and so-called hydro-polymerization. The resulting mixture of hydrocarbons contains no olefins and when isobutane and butenes are used the mixture contains not only the expected C_3 hydrocarbons, but also pentanes, hexanes, heptanes, nonanes, and small proportions of heavier hydrocarbons. These reactions take place at low temperatures, refrigeration being required.

It is now generally accepted that all of these alkylation results are best explained by the formation of carbonium ions. The low-temperature formation of the great number of hydrocarbons found in petroleum through the action of active-surface minerals must have a similar chemical mechanism.

Further evidence that the catalytic active-surface minerals play an important role in the formation of petroleum is found in the nature of the hydrocarbon constituents of typical petroleum. The fact that straight-run gasolines and kerosenes contain no unsaturated or olefinic hydrocarbons is a strong indication of this. Also the complexity of such oils or, in other words, the very large number of hydrocarbons, isomeric paraffins, naphthenes, and aromatic hydrocarbons, has no other plausible explanation. The great number of hydrocarbons present in petroleum was one of the primary considerations of the old destruction-distillation theory of Warren and Storer (30) and of Engler (9), but the relatively high temperatures postulated by Engler, and recently by Rossini, are clearly beyond consideration.

The extremely great differences in the composition of petroleum and the wide variations in the composition of gasoline fractions have been noted and are shown in the following tables. Some differences in petroleum could be expected as a result of differences in composition or types of organic material which constituted the original source material, but such differences in source material could not possibly account for the greater number of hydrocarbons which are evidently present in all petroleum. Some recent investigators have called attention to the fact that paraffins are found in nature in many plants, being formed by biochemical processes in the living plants. Some unsaponifiable hydrocarbon oil has been found in material extracted from decaying algae. However, it should be pointed out that when paraffins occur in nature, only one or two paraffins are formed and at most,

not more than four in any occurrence, and practically all of them are normal paraffins having an odd number of carbon atoms. They were apparently formed by loss of CO_2 from fatty acids which are found associated with these paraffins. Isomeric paraffins, naphthenes, or aromatic hydrocarbons, have not been found in such relations. In the decay of organic matter containing fatty oils, the hydrolysis to free fatty acids, the formation of insoluble soaps, loss of CO_2 , and polymerization have been observed and probably take place very early in the sequence of changes which form petroleum (26). But the formation of more than a very few normal paraffins by any biochemical process, including bacterial fermentation, has never been observed.

Consideration of all these facts, and particularly the complexity of petroleum composition, leads directly to the conclusion that petroleum origin involves two general processes: (1) conversion of the organic source material into heavy, bituminous material approaching a hydrocarbon mixture in over-all composition and, (2) what might be termed the "chemical dispersion" of this essential hydrocarbon material into the great series of paraffins and isomeric paraffins from methane to the solid waxes and also naphthenes and aromatic hydrocarbons. The very heavy viscous oils, many of them free from the lighter hydrocarbons such as gasoline, probably represent petroleum in a very early transition stage. There are many such tarry oils in the so-called tar sands, for example, the very heavy asphaltic oil in the upper sands of the Maracaibo basin.

Barton arrived at a similar conclusion in his study of Gulf Coast oils and their geology:

Evolution of crude oil from an original oil, perhaps something like the heaviest end of the residuum of the present Miocene Gulf Coast crude oils . . . (2, p. 137). The tentative deduction follows that the ancestral crude oil of the Gulf Coast crude oils was a heavy oil which, under the United States Bureau of Mines method of analysis would consist of residuum. Oils of that type should be too thick and viscous to move except through open channels. They may never be found in appreciable accumulations and may have to be sought as droplets scattered through the source formation (2, p. 139).

In considering this suggestion of the role of the catalytic action of active-surface minerals, we may summarize the limitations which appear to be imposed by the geologic history, physical conditions, and possible differences in environment which have to be considered in any attempt to account for the differences in type and composition of petroleums.

1. Maximum temperatures varying from 80°F. to 250°F.
2. Maximum pressures varying from possibly as low as 1,500 pounds per square inch to 6,000 pounds per square inch
3. Time since deposition of original source sediments varying from 10 to 350 million years (to Middle Ordovician)
4. Contact with clays and sands of varying catalytic effects
5. Unknown differences in type and chemical composition of original source material
6. Selective adsorption during migration

Some of these factors have already been discussed. High pressures have often been assumed to have been a factor in the formation of petroleums. It is very

doubtful, however, if pressures have been a factor of any importance. As indicated by observed bottom-hole pressures, these pressures vary from 1,500 pounds, or even less, per square inch, to the higher pressures found in deep wells in the range from 3,000 to 6,000 pounds per square inch. The observed pressures are seldom as great as the calculated hydrostatic head corresponding with the depth. Such pressures are hardly enough to influence chemical changes in the oil mixture. Thus it is frequently assumed that pressures would bring about polymerization of any unsaturated hydrocarbons originally present. As against this it may be pointed out that Conant and Petersen (6) found that high pressures up to 15,000 atmospheres did not cause the polymerization of such very reactive, unsaturated hydrocarbons as isoprene and butadiene unless such material had previously been subjected to oxidation with the formation of peroxides which in themselves are well known polymerizing catalysts. They concluded that such high pressures alone, which are many times greater than those encountered in oil fields, can not cause polymerization of even such very reactive dienes.

Changes in petroleum by selective adsorption during migration are well known and need not be reviewed here.

If the catalytic action of active-surface minerals, such as clays, has been a factor in producing the chemical changes noted by Barton in the Gulf Coast fields then it might be expected that oils found in reservoir rocks, such as limestones, which have no catalytic action on hydrocarbons might be found to be inconsistent with the regularities noted by Barton. Once petroleum has migrated into a limestone reservoir rock it should undergo little or no further chemical change. An oil might even have been subjected to such catalytic action and have been converted into a relatively light crude before migrating into a limestone reservoir. Actually we do find many examples of very heavy oils containing little or no light constituents, such as gasoline, occurring in limestone reservoirs even though we would expect from their geologic age and depth that they would be much lighter and more paraffinic. Such oils are the very heavy, asphaltic crudes in Mexico, for example the Panuco crude which is found in a Cretaceous limestone. A research committee of the Tulsa Geological Society, including H. M. Smith of the United States Bureau of Mines, in a study of Mid-Continent oils (20) has shown that the Arbuckle limestone in southeastern Kansas contains a heavy, asphaltic oil containing none of the lighter fractions, and this is in great contrast to the lighter typical Mid-Continent crudes from much younger formations. The crude oil from the Trenton limestone of the Lima-Indiana field is much heavier, more naphthenic and contains much less gasoline than the geologically more recent oil of the Bradford sand of Pennsylvania.⁵

Differences in the catalytic activity of different formations in contact with crude oil may also account for the very puzzling fact that crude oils, considerably different in composition, are found in some places separated vertically by only

⁵ Further inquiry into the composition of oils produced from limestone reservoir rocks is being made by the writer with H. M. Smith.

100-200 feet without any unconformity between the two producing formations. In such cases, the two oils must be of substantially the same geologic age and must have been subjected to substantially the same temperatures and pressures throughout their history. Smith and his associates suggested that such differences in crude composition may have been due to differences in the original environment of the source material or differences in the chemical composition of the original source material. There seems to be no tangible evidence for such assumed original differences but the observed facts may very plausibly be due to differences in the catalytic activity of the strata with which the oil has been in contact.

CATALYTIC ACTION IN RELATION TO CHEMICAL COMPOSITION

In catalytic cracking at high temperatures, it has been shown that different catalysts, under the same conditions of temperature, produce gasolines of some-

TABLE III
CHEMICAL COMPOSITION OF LIGHT PARAFFIN-NAPHTHENES FRACTION
40°-102°C. OF U. S. STRAIGHT-RUN GASOLINES

Gasoline	Percentage by Volume			
	Normal Paraffins	Isoparaffins	Cyclopentanes	Cyclohexanes
Ponca, Okla.	35.7	20.5	23.4	20.4
East Texas	24.7	27.3	26.0	22.0
Bradford, Pa.	34.4	32.2	13.4	20.0
Greendale-Kawkawlin, Mich.	63.1	13.2	8.0	15.7
Winkler, Tex.	9.5	61.6	8.4	20.5
Midway, Cal.	10.0	21.5	41.0	27.5
Conroe, Tex.	18.2	20.3	17.3	44.2

what different composition. Thus an alumina-silica catalyst produces a larger proportion of butanes and butenes and a gasoline of a little higher octane value than a silica-magnesia catalyst.

Table III shows the percentage of normal paraffins and isoparaffins in the low-boiling fraction 40°-102°C. of straight-run gasolines from seven crude petroleum investigated by F. D. Rossini and his associates at the United States Bureau of Standards (22). It is particularly noteworthy that this fraction from the Michigan petroleum contains 63.1 per cent normal paraffins and 13.2 per cent isoparaffins. In the Winkler, Texas, gasoline, these are nearly reversed, 9.5 per cent normal paraffins and 61.6 per cent isoparaffins.

Both the Michigan and Winkler crudes are produced from old formations (Table I), and both fields show bottom-hole temperatures below 100°F. The Michigan crude is the older by at least 70 million years. These two gasolines show in a very striking way that the compositions of straight-run gasolines do not represent thermal equilibrium mixtures. On the basis of calculated stability, from thermodynamics, all straight-run gasolines should generally resemble the Yates and

Winkler gasolines, with respect to the relative proportions of iso- and normal paraffins. Again, if the composition of petroleum was determined by the action of heat alone, then all petroleum of substantially the same age and temperature history should be the same. This is not even approximately true. The differences are wide and capricious.

TABLE IV
CONTENT OF AROMATICS IN U. S. STRAIGHT-RUN GASOLINES (E.P. 180°C.)*

<i>Gasoline</i>	<i>Aromatic Content (Percentage by Weight)</i>
Ponca, Okla.	9.8
East Tex.	10.4
Bradford, Pa.	8.3
Greendale-Kawkawlin, Mich.	7.2
Winkler, Tex.	4.9
Midway, Cal.	8.0
Conroe, Tex.	27.6

* Possible deviations from these figures: ± 0.2 to 0.5 .

TABLE V
HYDROCARBON TYPES IN STRAIGHT-RUN GASOLINES

<i>Crude Oil</i>	<i>End Point (°C.)</i>	<i>Percentage by Weight</i>		
		<i>Aromatics</i>	<i>Naphthenes</i>	<i>Paraffins</i>
Oklahoma City, Okla.	177	10	29	61
Tonkawa, Okla.	150	9	35	56
Tonkawa, Okla.	210	12	37	49
Davenport, Okla.	150	8	28	64
Davenport, Okla.	210	11	28	61
East Texas	159	6	42	52
Mexia, Tex.	150	22	21	57
Mexia, Tex.	210	18	21	61
Rodessa, La.	160	10	20	70
Santa Fe Spr., Cal.	151	10	50	40
Kettleman Hills, Cal.	151	8	45	47
Signal Hill, Cal.	153	6	52	42
Huntington Beach, Cal.	155	7	49	44
Huntington Beach, Cal.	210	11	54	35
Turner Valley, Canada	150	11	38	31
Turner Valley, Canada	200	15	35	50

The catalytic activity of different active-surface minerals and synthetic catalysts varies considerably and, as in catalytic cracking, may influence the character of the hydrocarbons produced. In the manufacture of synthetic gasoline from carbon monoxide and hydrogen, a cobalt catalyst yields a gasoline consisting largely of normal paraffins and having an octane number below 40, while an iron catalyst under substantially the same conditions gives a gasoline low in normal paraffins and having an octane number of 75 or higher.

Table III shows a wide variation in the ratio of cyclopentanes to cyclohexanes, from a ratio of 41:27.5 to 8.4:20.5. Table V shows a wide variation in the proportions of aromatics and naphthenes, from 22 aromatics and 21 naphthenes (Mexico, Texas, gasoline), to 6 aromatics and 52 naphthenes (Signal Hill, California, gasoline).

F. D. Rossini (21) under whose direction the thorough and painstaking analyses of gasolines were made at the Bureau of Standards, has recently pointed out that the relative proportions of certain selected constituents correspond approximately with the proportions required by thermal equilibrium mixtures at about 400°C., or 752°F., and that this should be taken into account in any theory of petroleum origin. It is apparent, however, and acknowledged by Rossini, that when the complete analyses and all the constituents are considered, none of them corresponds in composition with equilibrium conditions at any temperature. Such a temperature of 752°F. is a higher temperature than was employed in the Burton cracking process. Such conditions are clearly precluded as factors in petroleum formation by both the known physical conditions and much other chemical evidence.

FORMATION OF AROMATIC HYDROCARBONS

The apparently universal occurrence of aromatic hydrocarbons in petroleums, isolated and identified in straight-run gasolines, presents special difficulties. The proportions of aromatic hydrocarbons in various gasolines is given in the foregoing tables. In a few gasolines, such as that from Conroe, Texas, and certain of the Bornéo crudes, the percentage of aromatics is very large. No type of abundant and widely occurring possible source material contains aromatic groups sufficient to account for the presence of the aromatic hydrocarbons by any processes of simple degradation. Lignin and humic acids are the only natural materials occurring in abundance in nature which contain the benzene nucleus in its complex structure, but they are almost certainly absent from the organic matter in marine deposits. They probably contribute to the formation of coal but not petroleums. The formation of aromatic hydrocarbons from paraffins has been treated from the thermodynamic standpoint by A. W. Francis (10) who states that temperatures in the range 550–900°C. are required, assuming the splitting-off of hydrogen. According to Francis, the reactions possible below 550°C. are different in kind, so that at the lower temperatures the formation of aromatics from paraffins could not be expected even during geologic time. Experimental work bears out Francis' conclusions very well, so far as paraffins are concerned, although his temperature of 550°C. may be about 50°C. too high. The conclusions of Francis are very well confirmed by Taylor and Turkevich (27).

There is a very extensive published record on catalytic dehydrogenation, and the dehydrogenation of cyclohexane and its derivatives to benzene and its derivatives is a reversible process. The lower temperatures, in the presence of hydrogen, favor the conversion of benzenes to cyclohexanes, this reaction proceeding well experimentally at temperatures as low as 80–100°C. with active catalysts. The

dehydrogenation of cyclohexene to benzene in the presence of catalysts becomes noticeable experimentally at 170°C. Such temperature conditions appear to be ruled out by the temperature ranges within which the formation of petroleum and subsequent changes occurred. Perhaps more significant is the fact that cyclohexene in the presence of certain catalysts undergoes hydrogen disproportionation, being rapidly converted to benzene and cyclohexane, and pinenes are converted by fuller's earth to cymene and para menthane, probably through the intermediate formation of terpinene, with evolution of considerable heat.

According to Herington and Rideal (15), the formation of aromatics from paraffins in the presence of a chromium oxide-on-alumina catalyst at 887°F. (475°C.), proceeds through the formation of a mono-olefin. In commercial catalytic cracking at 930°-950°F. the formation of aromatic hydrocarbons is substantial, but at such high temperatures the mechanism of their formation is not clear.

PETROLEUM IN TRANSITION STAGES

Barton, in his study of Gulf Coast oils concluded that the extrapolation of his graphs representing composition, to more recent geologic time and relatively shallow depth, would indicate a heavy bitumen too viscous to flow and collect in large quantities. Such material would remain disseminated in the strata in which it occurred until it had changed in composition and had become sufficiently fluid to flow and migrate. Other considerations lead to the same conclusion. Thus, if the original organic source material, as laid down in the unconsolidated sediments, is solid or semi-solid, such physical changes must occur later. In view of the existence of such crude oils as those in the Pliocene of the Midway field in California, it is evident that if the oil or the material from which it has been derived is in contact with catalytic active-surface minerals for 10 million years, possibly a much shorter time is sufficient to form petroleum of the Midway type. This transition period in the chemistry of oil formation is now an almost completely unknown gap. Such material undoubtedly exists in many locations. If still disseminated it would have to be recovered by extraction. Such material awaits investigation.

It is possible that the black heavy oils in geologically recent so-called tar sands would well repay investigation from this point of view, as would also heavy asphaltic naphthenic oils. The non-fluid disseminated bituminous material which is assumed to exist should represent a still earlier stage in the chemical transition.

The observation of Pyhälä (19), in a study of two Russian oils, that the distillates contained many times the proportions of naphthenic acids as could be extracted from the crudes, suggests that saponification numbers would be of interest in the study of heavy naphthenic oils and bitumens in transition stages. Olefinic unsaturation should be looked for. Olefins are certainly not present in the lighter fractions of straight-run gasolines but there is reason to suspect the presence of high molecular weight olefin polymers in the higher-boiling viscous fractions, distilled at very low pressures. The study of such material in transition stages should show whether the sulphur, present in some crude oils up to about 5

per cent sulphur, is derived from the original source material or is acquired by later reactions.

SUMMARY

The evidence for the catalytic action of active-surface minerals in the formation of petroleum follows:

1. A low-temperature history, with a temperature range of 80°-225°F.
2. Calculated stability of paraffins, as regards heat alone
3. Complexity of petroleum, absence of olefins and presence of large number of hydrocarbons, including isomers
4. Evidence of change in composition with age and depth at previously noted temperature range
5. Catalytic activity for changes in hydrocarbons is not limited to fuller's earth, but is widespread among clays, shales, sandstones, and other mineral substances
6. Catalytic activity of active-surface minerals is most plausible explanation of presence of aromatic hydrocarbons in petroleum

OTHER RECENT THEORIES

Brief mention should be made of recent researches seeking to explain petroleum origin by bacterial action and by the effect of alpha radiation from radioactive minerals upon methane or upon the original organic source material of petroleum.

With respect to bacterial action, it is well known that methane is formed by bacterial action on cellulose. However, the formation of hydrocarbons, other than methane, in this way has never been observed and this appears to be a specific bacterial degradation of cellulose. Methane in relatively small amounts is commonly observed in coal deposits, but is not accompanied by the series of methane homologs found together with methane in natural gas. These two occurrences of methane appear to be entirely unrelated.

Loss of CO₂ from fatty acids has been observed in anaerobic fermentations, and the destruction of petroleum oils by bacterial action (33) under aerobic conditions, probably by oxidation, has been reported by several observers.

NATURAL GAS AND RADIOACTIVITY THEORY OF PETROLEUM ORIGIN

S. C. Lind (17) showed that the action of alpha radiation from radioactive material on gaseous hydrocarbons results in the splitting-off of hydrogen and the formation of a complex mixture of liquid hydrocarbons. He mentioned that the rocks of the earth's crust are universally radioactive, although in very low intensity. The oily products formed under such conditions are highly unsaturated. Lind considered this an objection to such a theory of petroleum origin. The unsaturated hydrocarbons could be polymerized, but the disappearance of hydrogen would be more difficult to explain. However, the non-reactive by-product helium should persist. Helium rarely occurs in natural gas, and its occurrence, from 0.5 to 2.0 per cent in some of the natural gases in northern Texas, western Kansas, and Oklahoma, is explained by the proximity of old buried granite ridges and the Shinarump conglomerate of Colorado, which contains carnotite (3). The gases richest in helium contain no hydrogen. In a private communication Lind states

that he is unable to see any solution of the hydrogen and helium difficulty.

To assume that hydrocarbon gases, or methane, is the parent substance of petroleum would still leave unexplained the origin of the methane. Sheppard and Whitehead (24), however, queried the action of alpha radiation on the buried organic matter in the sediments. Their very painstaking and careful work showed that CO_2 is split out of fatty acids.

There can be no doubt, of course, of the experimental results. However, the principal objections to the theory that petroleums have been formed from either methane or buried organic matter in the sediments by radioactivity are probably the following: (a) the composition of natural gas, the complete absence of hydrogen, and only the uncommon presence of helium; (b) lack of relation between the abundance of petroleum and natural gas and the proximity of radioactive minerals (intensity of alpha radiation); (c) the absence of olefinic unsaturated hydrocarbons in gases or petroleums. If the process is, as stated, dependent on the widespread radioactivity of low intensity, then the process must be a continuing one and unsaturated hydrocarbons and hydrogen would be expected. The most serious discrepancy between the observed facts and the alpha-radiation theory is that the outstanding experimental result of the action of alpha radiation on hydrocarbons is that it knocks off hydrogen atoms. Such continued action would produce progressively heavier oils poorer in hydrogen. This is contrary to the observed facts with respect to the geologically old, light paraffinic crudes. (d) Optically active hydrocarbons in petroleum could not be expected, but petroleums do contain slightly optically active hydrocarbons. (e) Substances found in petroleums and derived from organic matter buried in the sediments, such as chlorophyll porphyrins, naphthenic acid complexes, nitrogen bases, and labile sulphur complexes, must either escape destruction by alpha radiation or these substances must be picked up subsequently by the oil, possibly during migration. In 1944, Sheppard (24, p. 948) concluded,

In this survey of the origin of petroleum from the physicist's point of view, no conclusions can be drawn as to whether or not radioactive processes are significant in petroleum genesis.

In this connection, it should be noted that marine shales, rich in kerogen, show exceptionally high radioactivity, but as already noted, such shales may be geologically very old, rich in organic material, and contain little or no oil as such.

Finally, when oil (or gas) does come into contact with radioactive minerals, extensive decomposition with carbon formation occurs, as shown by the mineral thucolite. In Canadian pegmatites, near Perry Sound, Ontario, and near Buckingham, Quebec, the mineral thucolite occurs, in some places as a pseudomorph after uraninite. Analyses showed the mineral to contain 50.8 to 61.5 per cent carbon, 2 per cent moisture, 20 per cent volatile hydrocarbons (gases), and 16.6–26.8 per cent ash, consisting largely of uranium and thorium oxides (25). Crevices and cracks in the adjacent pegmatite rock contained an oil substance which ap-

parently had seeped into the pegmatite from the country rock subsequent to the intrusion of the pegmatite. Thus the action of the radioactive material on the oil was apparently extremely local and resulted in the formation of carbon and gases, a result to be expected from the experiments showing splitting-off of hydrogen.

REFERENCES

1. BAILEY, J. R., in *The Science of Petroleum* (1937), p. 1047.
2. BARTON, D. C., *Problems of Petroleum Geology*, Amer. Assoc. Petrol. Geol. (1934), pp. 109-55.
- 2a. ———, *Jour. Inst. Petrol. Tech.*, Vol. 20 (1934), p. 206.
3. BOTTOMS, R. R., *The Science of Petroleum*, p. 1517.
4. BROOKS, B. T., *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15 (1931), pp. 611-27. *The Science of Petroleum* (1937), p. 46.
5. ———, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20 (1936), pp. 280-300.
6. CONANT, J. B., AND PETERSEN, W., *Canadian Jour. Research*, Vol. 34 (1934), p. 921.
7. DOBBIN, C. E., *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 27 (1943), pp. 417-78.
8. ELLS, S. C., in *Shale Oil*, edited by R. H. McKee (New York, 1925), p. 49.
9. ENGLER, C., *Ber. der Deutschen Chem. Ges.*, Vol. 21 (1888), p. 1816; Vol. 30 (1897), p. 2365; *Zeit. für Angew. Chemie*, Vol. 25 (1912).
10. FRANCIS, A. W., *Indus. and Eng. Chemistry*, Vol. 20 (1928), p. 277.
11. FROST, A. V., *Chem. Abs.* (1946), p. 4499.
12. GAYER, F. H., *Indus. and Eng. Chemistry*, Vol. 25 (1933), p. 1122.
13. GURWITSCH, L. G., *Jour. Chem. Soc., abs.*, Vol. 108 (1915), p. 933.
14. HEALD, K. C., "Study of Earth Temperatures in Oil Fields," *Bull. Amer. Petrol. Inst.* (1930), p. 205.
15. HERINGTON, E. F. G., AND RIDEAL, E. K., *Proc. Roy. Soc. London*, A184 (1945), p. 434.
16. KEWLEY, J., *Jour. Inst. Petrol. Tech.*, Vol. 20 (1934), p. 195.
17. LIND, S. C., *Science*, Vol. 73 (1931), p. 19; *The Science of Petroleum* (1937), p. 39.
18. MCCOY, A. W., AND KEYTE, W. A., *Problems of Petroleum Geology*, Amer. Assoc. Petrol. Geol. (1934), pp. 253-307.
19. PYHALÄ, E., *Chem. Zeitung*, Vol. 57 (1933), p. 273.
20. RESEARCH COMMITTEE, TULSA GEOLOGICAL SOCIETY, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 31 (1947), p. 92.
21. ROSSINI, F. D., *Amer. Chem. Soc. meeting*, Houston, Texas, December, 1947.
22. SACHANEN, A. N., *Chemical Constituents of Petroleum* (New York, 1945), p. 201.
23. SEYER, W. F., *Jour. Inst. Petrol. Tech.*, Vol. 19 (1933), p. 733.
24. SHEPPARD, C. W., AND WHITEHEAD, W. L., *Jour. Amer. Chem. Soc.*, Vol. 68 (1946); *Jour. Phys. Chem.*, Vol. 50 (1946), p. 119; *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 28 (1944), p. 924.
25. SPENCE, H. S., *Amer. Mineralogist*, Vol. 15 (1930), p. 499.
26. STADNIKOFF, G., *Die Entstehung von Kohle und Erdoel*. Enke, Stuttgart (1930).
27. TAYLOR, H., AND TURKEVICH, A. L., *Trans. Faraday Soc.*, Vol. 35 (1939), p. 921.
28. TRASK, P. D., AND HAMMAR, H. E., *Origin and Environment of Source Sediments of Petroleum* (Houston, 1932).
29. TREIBS, A., *Ann. d. Chem.*, Vol. 510 (1934), p. 42; Vol. 517 (1935), p. 172; Vol. 520 (1935), p. 144; *Chem. Abs.*, Vol. 32 (1938), p. 4482.
30. WARREN, C. M., AND STORER, F. H., *Amer. Acad. Arts and Sci.* (2), Vol. 9 (1865), p. 177.
31. WASHBURN, C. W., *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 3 (1919), p. 345.
32. WHITMORE, F. C., and MARSHNER, R. F., presented at *Amer. Chem. Soc. meeting*, April, 1935.
33. ZOBELL, C., *Science*, Vol. 102 (1945), p. 364; *Bacteriol. Rev.*, Vol. 10 (1946), p. 1.

GEOLOGICAL NOTES

POSSIBLE ANCIENT SUBMARINE CANYON IN SOUTHWESTERN LOUISIANA¹

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Recent deep drilling in the Johnson's Bayou area, in the extreme southwestern part of the Louisiana Gulf Coast, in Cameron Parish, disclosed interesting facts, leading to the conclusion that a large ancient submarine canyon existed in this area which was subsequently filled with more recent sediments.

The early development history of the Johnson's Bayou area was described by James H. McGuirt.³

Although some additional drilling has been done since the writing of McGuirt's report, it was not until September, 1944, that deep drilling was commenced. Prior to this first deep test (Gulf Oil Company's M. Gray 1-C, Sec. 15, T. 15 S., R. 14 W.), the deepest well was the Magnolia Petroleum Company's School Board 1, Sec. 16, T. 15 S., R. 14 W. This well, drilled in 1936, reached the depth of 9,180 feet and was abandoned in shale which at that time was thought to represent the *Discorbis* zone of the Louisiana Gulf Coast Miocene section. The Gulf's deep test, drilled to 11,840 feet, proved that this shale represented a marine wedge of the upper Miocene and that it was underlain by an enormous thickness of alternating sands and shales. The total thickness of this shale section, nearly 3,600 feet, was revealed in another deep test drilled by the Continental Oil Company, jointly with the Yegua Corporation, in Sec. 9, T. 15 S., R. 14 W. This well reached the depth of 13,008 feet and was abandoned in shale representing the *Heterostegina* zone or possibly the *Marginulina* zone. The sparsely fossiliferous sand and gray shale section below the marine Miocene wedge extended from 8,950 feet to 12,550 feet where it abruptly broke into marine, fossiliferous shale which carried a microfauna characteristic of the lower *Heterostegina* zone. The shale extended to the bottom of the hole. A core taken at 12,998-13,006 feet recovered very hard dark shale with a few "sandy" streaks made up almost entirely of *Globigerina* tests. The presence of a "*Globigerina* ooze" suggests that this shale was deposited in a sea of considerable depth. According to Twenhofel,⁴ *Globigerina* oozes are found at depths ranging from 400 to 2,925 fathoms.

¹ Manuscript received, July 28, 1948.

² District geologist, Continental Oil Company; now research geologist for the company, at Houston, Texas.

³ J. H. McGuirt, "Reports on the Geology of Cameron and Vermilion Parishes," *Louisiana Geol. Survey Geol. Bull. 6* (1935), pp. 169-71.

⁴ W. H. Twenhofel, *Principles of Sedimentation* (1939), p. 127.

Another interesting geological feature was revealed in this well with regard to the dip of the beds. Cores taken in the thick sand and shale section overlying the *Heterostegina* shale showed the beds dipping about 30° , but cores in the *Heterostegina* shale displayed considerably less dip, only 10° – 15° .

A third deep test, drilled by the Sohio Petroleum Company in Sec. 12, T. 15 S., R. 14 W., 2 miles northeast of the Gulf's deep test, encountered beds down to

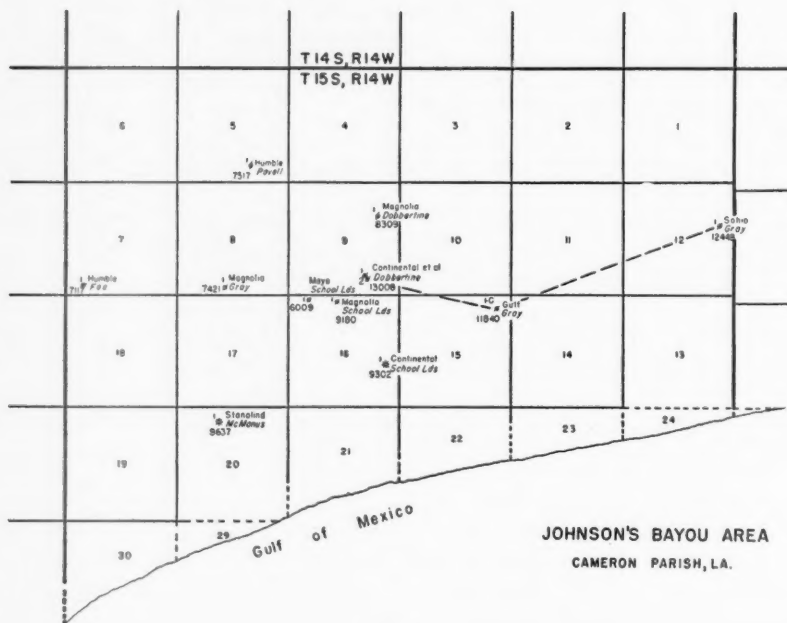


FIG. 1

9,300 feet very similar to the beds in the Continental and Gulf wells, but at greater depths they were almost entirely marine and shallow marine shales, containing the normal microfaunal sequences of the general area, thus differing markedly from the evidently abnormal sand and shale in the Continental and Gulf wells.

Figure 2 shows a tentative correlation between the three deep tests. It suggests that the thick sand and shale section in the Continental and Gulf wells below 9,000 feet represents a channel fill, deposited in a submarine canyon which was cut into the slope of the continental shelf after the deposition of the sediments of the *Discorbis* zone. This canyon was filled with deltaic sediments prior to the deposition of the *Bolivina floridana* zone, probably in connection with the regression of the *Discorbis* zone sea.

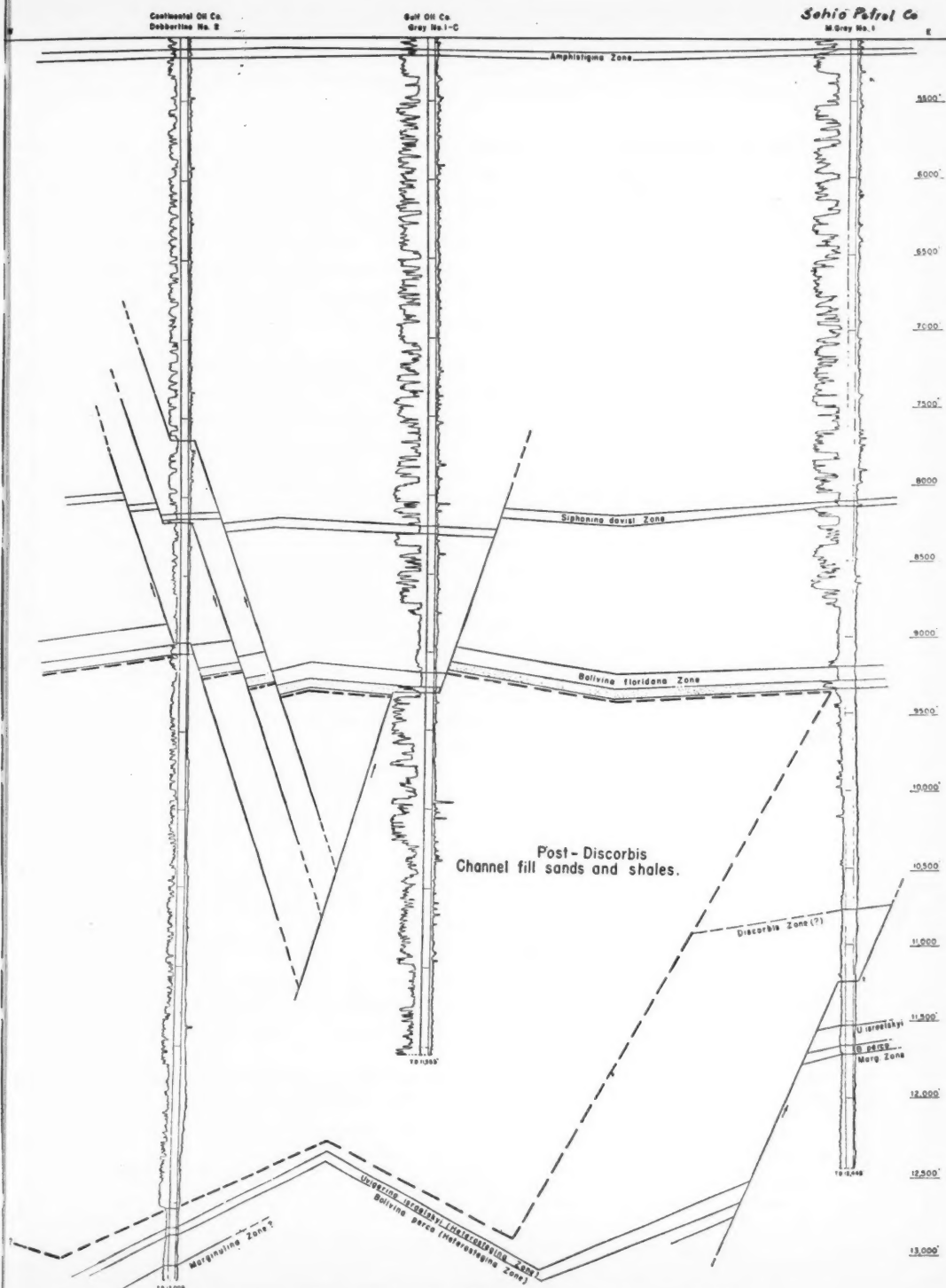


FIG. 2.—West-east section through Johnson's Bayou area, Cameron Parish.

The structural interpretation shown on the cross section is very sketchy as the true structural conditions of the Johnson's Bayou area are not yet clearly revealed. They are undoubtedly more complicated through faulting.

Unfortunately no deep wells have been drilled directly west of the Johnson's Bayou prospect which would help to establish the western wall of this possible submarine canyon. A well of The Texas Company about 7 miles northwest of the Continental's Dobbertine 2, near the eastern shore of Sabine Lake, encountered a section similar to that found in the Sohio deep test. This well may be on the west side of the canyon.

An ancient submarine channel in the Gulf Coastal Plain of Louisiana has been reported by W. J. Osterhoudt.⁵ However, the canyon in the Johnson's Bayou area appears to be older and is probably more comparable in form and size with the well known recent submarine canyon on the continental shelf slope south of Barataria Bay (Jefferson Parish).⁶

An attempt was also made to explain the abnormal stratigraphic conditions of the Johnson's Bayou area as the result of faulting alone. For instance, it could be assumed that the sand section below the *Bolivina floridana* zone in the Continental Dobbertine 2 is faulted out in the Sohio Petroleum Company's Gray 1, or that the lithologic break at 12,550 feet in the Continental's Dobbertine 2 does not constitute an unconformity but a major fault with the downthrown side toward the coast. This fault may have been active during the deposition of the post-*Discorbis* sediments, these sediments being laid down in front of a growing submarine fault escarpment. However, as such fault interpretations appear to be considerably more speculative at the present than the channel interpretation, the writer gives preference to the latter explanation.

TEMPLATE FOR SPACING STRUCTURE CONTOURS¹

JOHN C. CROWELL²
Los Angeles, California

In drawing structure-contour maps, observed dips from cores, outcrops, or dipmeter readings must coincide with the dip indicated by the spacing of the structure contours. A transparent plastic template can be constructed (Fig. 1)

⁵ W. J. Osterhoudt, "The Seismograph Discovery of an Ancient Mississippi River Channel," paper presented before the Society of Exploration Geophysicists at Chicago, April, 1946.

⁶ U. S. Coast and Geodetic Survey Navigation Chart 1116.

¹ Manuscript received, October 11, 1948.

² Department of geology, University of California, Los Angeles. Appreciation for suggestions and criticism is extended to Professors Daniel I. Axelrod, Cordell Durrell, James Gilluly, and William C. Putnam, and for drafting to A. Cowles Daley.

to aid in drawing contours that fit the observed dips. This instrument can also be used to determine the degree of dip from contour spacing.

The template consists of a graph of the distance between two adjacent contours as a function of the amount of dip, for a particular map scale and contour

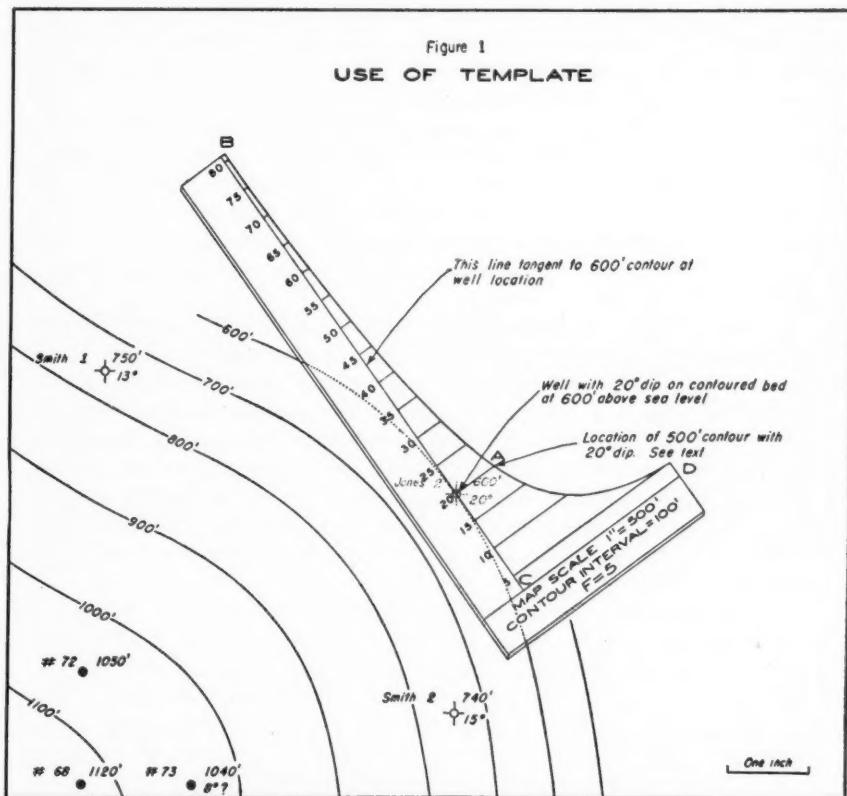


FIG. 1.—Diagram showing template and its use. Scale of this hypothetical map, before reduction, was 500 feet per inch with contour interval of 100 feet. The structure-contour lines are referred to sea-level.

interval. The coordinate, *CD* (Fig. 1), is drawn to the *same scale as the scale of the map under construction*. The other coordinate, *BC*, showing the dip values, is arbitrary and any convenient linear scale can be selected. If this graph is drawn on a piece of transparent plastic, and then carefully cut out, it can be moved from place to place over the map, and the compatibility of the observed dips with the contour spacing ascertained immediately.

The relation used for determining the contour spacing from the dip value is

$$\text{Distance between contours} = \text{Contour interval} \times \text{Cotangent of dip angle.}$$

Values obtained from this relation are then plotted to the scale of the map.

The use of the template is illustrated in Figure 1. The reference line *BC*, or the zero line of the graph, is placed tangent to the structure contour through or near an observed dip. The point of tangency coincides with the number of degrees of dip as marked along the *BC* coordinate. In Figure 1, a core with a 20° dip, assumed to come from a vertical hole, is used as an example. The distance to the next contour is found at *A*, where the curve of the graph intersects the 20° coordinate. Used in this manner, the template gives the spacing only if the dip between the well and point *A* is uniform and equal to 20° . The steepening of the dip toward *A*, suggested by the contour spacing over the map, can be allowed for easily in practice by moving the template from place to place. In fact, some kind of interpolation will normally be necessary since contours seldom pass through wells and the dip is rarely uniform.

Since the template can be easily constructed it is desirable to have a different instrument available for each contour interval and map scale so that errors will not arise due to an inadvertent selection of the wrong scale. Several curves for different map scales and contour intervals can be etched on one piece of plastic, however, and used as aids in interpreting structure-contour maps already on hand. The scales and contour intervals selected will depend on those in use by any particular geological office. If desired, small holes can be punched at the intersections of dip lines and curves, in the same way that lettering triangles are constructed. A sharp pencil can then be inserted through the holes and points plotted during map construction.

The relation between scale and contour interval is such that the spacing will be the same if the scale is doubled and the interval halved. That is, the spacing is the same for a 100-foot-to-the-inch scale with a 25-foot contour interval as for a 200-foot-to-the-inch scale with a 50-foot contour interval. This means that a factor (*F*) is equal to 4 in both cases, where *F* is defined as the quotient of the scale in feet to the inch divided by the contour interval in feet. By using this factor (*F*) a family of curves can be drawn (Fig. 2), which will include a graph giving the appropriate contour spacing for many combinations of map scale and contour interval. The curves shown in Figure 2 have been carefully drawn and are reproduced here in true scale so that anyone can construct a template for any desired *F* by merely tracing the curve on transparent plastic. Interpolated curves will have to be sketched for the values of *F* not included on the graph.

Similar templates are used by meteorologists to obtain wind speeds from the spacing of isobars on weather maps,³ and by oceanographers to construct "wave

³ Sverre Petterssen, *Weather Analysis and Forecasting*, pp. 215-20. New York (1940).

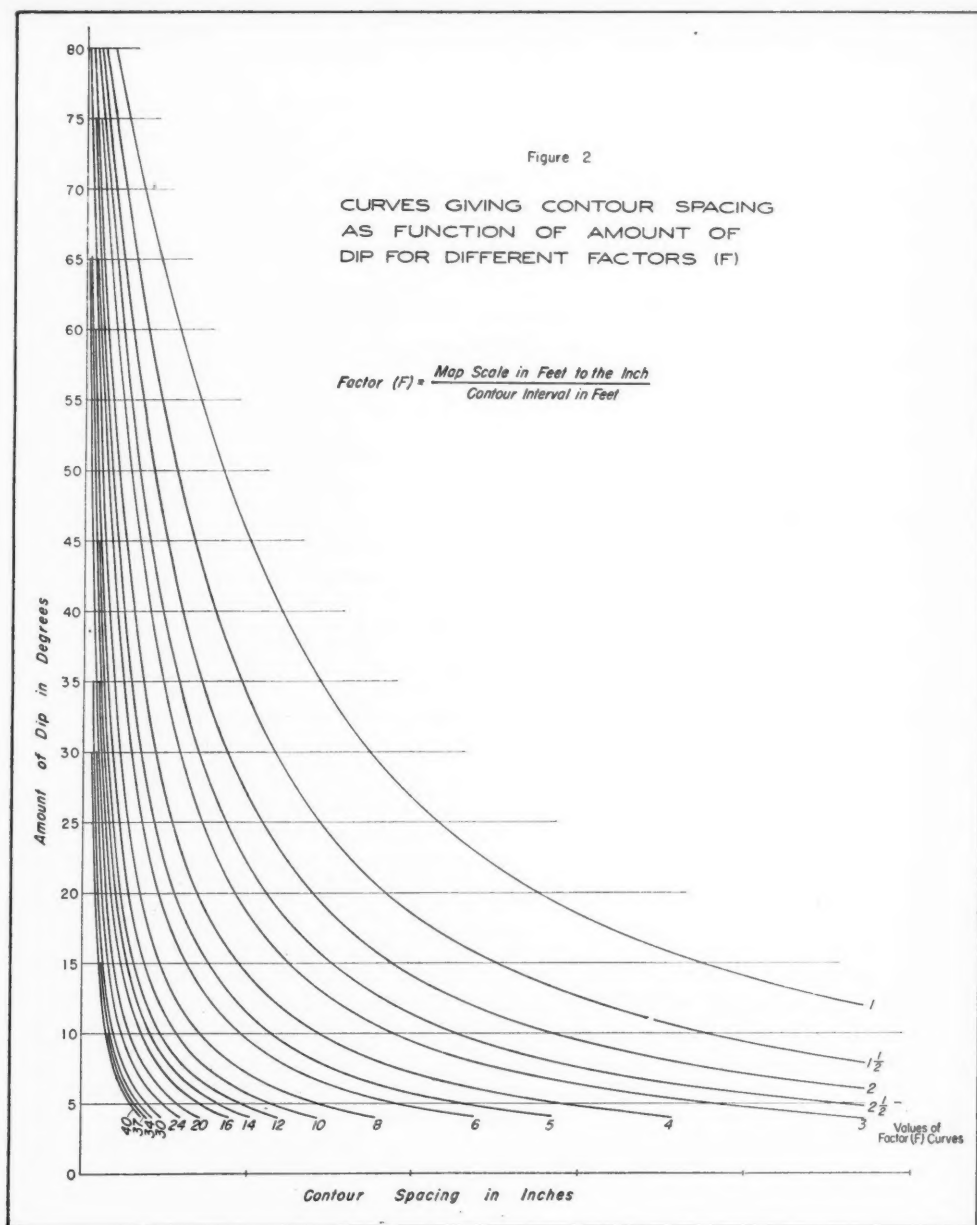


FIG. 2.—Curves giving contour spacing as function of amount of dip for different factors (F). These curves have been carefully drawn and reproduced to scale, so that template can be constructed quickly by following instructions.

1. Determine value of factor (F) in which you are interested by dividing your map scale in feet to the inch by contour interval in feet.
2. Select curve above corresponding with your value of F . Interpolate or compute a curve if necessary.
3. Trace curve and vertical and horizontal coordinates on transparent plastic. Label, cut out, and use as shown in Figure 1.

refraction diagrams."⁴ White has described a cotangent rule for simplifying many structural problems,⁵ but the instrument described here, which differs from his in design, is believed to be more useful in drafting and interpreting structure-contour maps.

⁴ U. S. Navy Hydrographic Office, *Breakers and Surf: Principles in Forecasting*, H. O. 234 (1944), p. 33.

⁵ Walter S. White, "A Cotangent Ruler for Simplifying the Graphic Solution of Problems in Structural Geology," *Econ. Geol.*, Vol. 41, No. 5 (August, 1946), pp. 539-45.

AMERICAN GEOLOGICAL INSTITUTE

Eleven national societies, representing the geological sciences, with a combined membership of more than 10,000 professional geologists, have completed arrangements for the organization of the American Geological Institute, to direct the talents of the geologic profession into more effective channels of national service, under the sponsorship of the National Research Council.

Directors of the Institute, named by the affiliated societies, held their first meeting in Washington, D. C., on November 15-16, to initiate immediate action aimed at speeding the discovery of additional reserves of scarce minerals, the detailed geologic mapping of the United States, greater recognition and use of geologists and the geologic sciences in governmental agencies and the armed services, the training of more geologists in colleges and universities to overcome the present critical geologic manpower shortage within the mineral industries, the improvement of educational standards in the geologic sciences, more effective dissemination of geologic research information, and greater public understanding and appreciation of the role of geology in modern civilization.

President of the new Institute is A. I. Levorsen, dean of the School of Mineral Sciences, Stanford University. Wm. B. Heroy, consulting geologist and geophysicist of Dallas, Texas, is vice-president, and Earl Ingerson of the United States Geological Survey, Washington, D. C., is secretary-treasurer.

National societies forming the Institute are the Geological Society of America, American Association of Petroleum Geologists, American Institute of Mining and Metallurgical Engineers, American Geophysical Union, Mineralogical Society of America, Society of Economic Geologists, Society of Exploration Geophysicists, Society of Economic Paleontologists and Mineralogists, Seismological Society of America, Paleontological Society, and Society of Vertebrate Paleontology.

Headquarters of the Institute will be established at the National Academy of Sciences, Washington, D. C., as soon as an executive secretary has been selected and appointed.

DISCUSSION

ONLAP AND STRIKE-OVERLAP¹

H. R. LOVELY²

London, England

In the October issue of the *Bulletin* an interesting and thought-provoking article³ appeared on the use of the word "overlap" in geological literature, and it was concluded therein that some modification of the current employment of this word was required in order to avoid confusion as to actual geological sense which was intended by any particular user of this term. It was stressed that this procedure is needed because in recent years the term "overlap" has been used to describe two different concepts of sedimentation.

(a) The regular and progressive pinching-out of sediments above unconformities.

(b) The regular truncation of sediments below unconformities.

It is also mentioned that the term has been used to represent a facies change from marine to continental sediments of equivalent age.

It is agreed that it is essential to differentiate clearly and exactly between these entirely separate geological conceptions, but the point seems to have been overlooked by Melton that the confusion to which he alludes is not caused by lack of adequate geological nomenclature but instead by loose geological thinking and improper use of descriptive terms which, though defined many years ago, are still entirely satisfactory if properly applied. In the writer's experience the two concepts (a) and (b) are already differentiated clearly and concisely by the terms "overlap" and "overstep," respectively. These terms are simple, and what is more, paint a word picture of the geological process which it is intended to describe. Thus, the word "overlap" suggests immediately, even to the student, the successive covering of layers of strata, each layer in turn extending farther than the underlying one. There is no ambiguity about this, and the fact that the word has been used to describe other geological concepts is no argument for discarding it, rather is it an incentive to more exact instruction in geological nomenclature to students, and more disciplined writing among professional geologists.

Similarly the term "overstep" in use before the application of geology to the petroleum industry, is an exact description of this geological concept, in that the younger strata "step" over the truncated edges of the older series. What could be simpler and yet at the same time so entirely adequate for the purpose.

It is in no way intended to be critical of a sincere attempt to clarify a state of confusion, even though this is quite unnecessary, but comparison of the suggested synonyms for the time-honored terms "overlap" and "overstep" with the latter lends to the unbiased conclusion that they are uninspiring and un-needed substitutes. While the word "over" in "overlap" suggests the process itself, the word "on" in "onlap" has no such significance, while "marine onlap" does not create a picture of any particular process in mind.

There is no excuse for the use of "overlap" to describe a facies change, such as the term "replacement overlap" as mentioned by Melton, such misuse of nomenclature can not help but lead to confusion, and it is difficult to see any reason whatever for such un-geological thinking.

¹ Manuscript received, January 19, 1948.

² Iraq Petroleum Company, Limited.

³ Frank A. Melton, "Onlap and Strike-Overlap," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 31, No. 10 (October, 1947), pp. 1868-78.

If, therefore, the confusion described in the original article does exist, then the present writer would suggest most strongly that the best course is to insist on proper use of the existing terminology.

It may be thought that the writer is unduly critical of what appears to be modern-day geological usage in the United States but it is thought that all will agree that the essential basis of any science is a clear, concise, and logical system of nomenclature which is accepted universally.⁴

REPLY BY FRANK A. MELTON, School of Geology, University of Oklahoma, Norman, Oklahoma: Mr. Lovely seems to have missed one of the main points of the writer's paper—that the slow regular regional truncation below unconformities is in a class by itself and needs separate recognition. The "overstep" which Page⁵ had in mind was no doubt observable in the field; a specific example of "strike-overlap" on the other hand, emerges as a valid concept only after extensive geological study and mapping, usually by many geologists. To say that strike-overlap is merely one of the examples of an idealized textbook illustration of "truncation," though strictly true, is, nonetheless, misleading, as field observers see only an absolute parallelism of beds above and below the unconformity—if indeed the unconformity is visible at all.

Mr. Lovely has lost his point about the word "overlap." In 1831⁶ H. T. De la Beche, who was in charge of the First Geological Survey of Great Britain, used the word overlap in the sense of strike-overlap or truncation of formations underlying an unconformity. As this antedates the Page and Lapworth reference, it would seem to require, for the sake of consistency, that Mr. Lovely abandon his late usage of the word, since it is entirely different from the early meaning. Likewise, the note by H. Elliott indicates that the use of the "so-called rule of priority" would require "overlap" to be abandoned as a stratigraphic term.

So far as the present writer is concerned it makes little difference whether geologists continue to use *overlap* or whether they adopt *onlap*. He believes, however, that the con-

⁴ In a letter from H. R. Lovely, dated March 24, 1948, he states: "It has since come to the writer's notice that the term 'overstep' is virtually unknown in the U. S. A. and little used so that the comments contained in this discussion must be considered to apply mainly to the use of the term 'overlap'."

The following Note signed by H. Elliott was included with the letter.

NOTE ON TERMINOLOGY OF STRATIGRAPHICAL OVERLAP PHENOMENA

Two of the terms used to indicate relationships of strata in unconformable succession are *overlap* and *overstep*; these are defined in *Chambers Technical Dictionary* (Rev. ed. 1943, Geol. Contr. A. K. Wells) as follows:—

1. Overlap.

The relationship between conformable strata laid down during an extension of the basin of sedimentation (for example, on the margins of a slowly sinking landmass) so that each successive stratum extends beyond the boundaries of the one lying immediately beneath.

2. Overstep.

The structural relationship between an unconformable stratum and the outcrops of the underlying rocks across which the former transgresses.

These terms, with meanings as given above, are in common use today. "Overlap" and "overstep" appear to date from 1888, when they were used to illustrate the phenomena defined above by Lapworth (12th ed. Page's *Text-Book Geol.*, 1888, p. 64). It should however be pointed out that the first use of "overlap" was by Page, who in the first six editions of his text-book (1st ed., 1856, p. 43; 2d ed., 1859, p. 64; 3d ed., 1861, p. 67; 6th ed., 1876, p. 83) used it to refer to the relationship of strata which had been folded over on to other strata—what we should today call recumbent folding or in certain circumstances overthrusting. It is obvious that application of the so-called "rule of priority" here would cause far more trouble than it would be worth.

⁵ David Page, *Introductory Textbook of Geology*. 12th ed., revised and in great part rewritten by Charles Lapworth. Blackwood and Sons (1888).

⁶ H. T. De la Beche, *Manual of Geology*.

fusion will disappear if *onlap* and *strike-overlap* are employed as he proposed in his paper. He is unable to find that the word *onlap* has ever been used in any sense other than the stratigraphical one. Hence, its use in this way is unencumbered by earlier meanings.

The present writer is forced to believe that Mr. Lovely is misguided when he implies that there is a "natural" or "obvious" meaning of the words *overlap* and *overstep*. How can anyone maintain that "the word 'over' in 'overlap' suggests the process" . . . of deposition in an advancing sea; and that "the word 'on' in 'onlap' has no such significance." It is perfectly clear that words such as "over" and "on" have the significance which one is accustomed to read into them, and do not have any inherent or natural meaning which students can comprehend immediately. These and similar words can not describe a natural process exactly unless rigorously defined to do so.

For example: in one of the authoritative books on word usage there may be counted: fourteen different meanings of *over* as an adverbial prefix, in the sense of "above" and "to"; twenty-three different meanings as a preposition in the sense of "above," "on, upon," "across"; more than twenty different meanings, in combinations with other parts of speech, as a verb in the "space" and "time" sense and in the sense of "over or beyond" in degree. This does not exhaust the usage of *over* as a verb, to say nothing of its use as an adjective and occasionally as a noun. Similarly, in the same source there may be counted more than thirty different meanings of "on" as a preposition in the sense of "position" and "motion or direction towards a position." *Who can say what is the implicit or inherent meaning of words such as these.*

The word *overstep* is an "uninspired" term because in more than 60 years of existence it has not succeeded in gaining any recognition among American geologists and very little in England. Only a few Americans have ever heard of the term, and none, to the writer's knowledge, uses it in textbooks or other publications.

There would be no point in pursuing this discussion further, if Mr. Lovely had not stated emphatically what is needed for the advancement of science, that is, "discipline." It is of course true in the more highly formalized sciences such as chemistry and physics, and also in the field of mathematics that a *disciplined* use of terms (meaning thereby a strict adherence to the original usage of terms) is of importance. At least it should be apparent that one has reasons for abandoning a term. Such disciplined usage is less important in the rapidly changing science of geology, and particularly in the new field of physical stratigraphy. Here an immediate need exists for new terms based on the facts of this new science which are being discovered with great rapidity by countless exploratory, surveying, and drilling operations. It is possible that the discipline which Mr. Lovely feels is needed so badly might even retard progress in physical stratigraphy by preventing the rapid advance in terminology which is needed.

This writer is not certain on the following point, but there is at least a possibility that the present backward state of stratigraphic knowledge is partly due to an over-zealous attention to the geological concepts presented in the original publications, and not enough attention to the facts of stratigraphy as revealed in the field and in well records. Stratigraphic terminology, which was largely developed in England and Europe, is inadequate for present needs. We could use many new compound terms, which by their nature reveal more about the processes than the older and more simple terms.

The history of science shows that great advances have been made by a clarification of ideas and the corresponding change in nomenclature. Occasionally a happy simplification of terms has opened new fields of thought. More often it was a refinement in meaning which involved the use of more terms; and sometimes merely the substitution of a more meaningful compound term for an older and simpler one. There has frequently been objection to a change in the dictionary of a science. Yet it is unquestionably true that advances in all science, including physical stratigraphy, will go hand in hand with the clarification of ideas and the corresponding invention of new and more revealing terms.

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library, and are available, for loan, to members and associates.

TEXAS GULF COAST OIL, BY FRANK J. GARDNER

REVIEW BY E. J. BARRAGY¹

Houston, Texas

Texas Gulf Coast Oil, by Frank J. Gardner. 332 pp., 61 pls., 9×11 inches, perforated plastic binding, heavy manila cover. Published by The Rinehart Oil News Company, Dallas, Texas (1948). Price, \$35.00; to subscribers of Rineharts Oil Reports, \$25.00.

This is a statistical compilation of information concerning all the commercial oil and gas fields in twenty-nine counties of the Upper Gulf Coast of Texas.

As treated in this publication, the Texas Gulf Coast is "District Three" of the Railroad Commission of Texas, extending from Jackson-Lavaca-Gonzales counties on the southwest to the Sabine River on the east. Counties included are: Austin, Brazoria, Brazos, Burleson, Chambers, Colorado, Fayette, Fort Bend, Galveston, Grimes, Hardin, Harris, Jasper, Jefferson, Lee, Liberty, Washington, and Wharton.

The volume is divided into: I. Introduction (1 p.); II. A Brief Tabulated History of Oil Development on the Texas Gulf Coast (2 pp.); III. Summary of the Oil Industry on the Texas Gulf Coast Today (4 pp.); IV. Tabulation of Industrial Plants in the Texas Gulf Coast Area (5 pp.); V. List of Oil and Gas Fields Included in Text, with Cumulative Production and Number of Producing Wells as of January 1, 1948 (5 pp.); VI. Compilation of Individual Field Data (307 pp.); VII. Bibliography (3 pp.); and Index (5 pp.).

Typical of the "Individual Field Data," to which most of the publication is devoted, is that for the Sugar Valley field of Matagorda County.

SUGAR VALLEY FIELD

LOCATION: 3 mi. NE Van Vleck, west of Sugar Valley and Grovedale, NE Matagorda Co. Surveys: P. Burnett; A. S. Sojourner; Amos Rawls; F. George A-40; F. Pettus.

EXPLORATION HISTORY: Reflection seismograph surveys by Ohio, Helmerich & Payne, and others. Several deep failures preceded discovery.

DISCOVERY DATA: Superior Oil Co. of California #1 F. B. Peterson, PT 154 BCPD & 5,029,000 CFGPD ($\frac{1}{4}$ " ch.), GOR 38,099-1, TD 11,854', June 16, 1943.* First oil well was Superior Oil Co. & J. H. Blaffer #1 W. J. Culbertson, PT 256 BOPD (16/64" ch.), TD 10,662', Feb. 6, 1946.

*Original discovery well reworked & recompleted Apr. 7, 1947, for PT 106 BOPD (10/64" ch.), TD 11,854' in sand 9,008-13' (first compl. in sand 9,754-64').

AVERAGE SURFACE ELEVATION: 50' grd. ACREAGE: Oil 2,100. Gas and/or Cond. 2,100.

STRUCTURE: Large anticlinal fold, closure and production on both upthrown (NW) and downthrown (SE) sides of normal strike fault, "South Valley" lies to SE of fault.

PRODUCTIVE HORIZONS:

Frio:

- 7,674-78' (Gas, 49° condensate)
- 8,274-76' (44° oil)—discovery oil sand
- 8,701-47' (gas, 53° condensate)—"Ashwood" (NW extension area)
- 8,761-86' (35° oil)
- 8,847-66' (33° oil)—"Talcott" sand ("Second Granbury" sand)
- 8,934-9,140' (34° oil)—"Hurlock" & "Lawrence" sands
- 9,298-9,315' (34° oil)—SE flank
- 9,754-64 (gas, 55° condensate)—discovery gas sand
- 9,943-85' (29° oil)—"Truitt" sand, "South Sugar Valley" area (down-thrown)
- 10,131-136' (29° oil)—South extension area

¹ Review received, October 8, 1948.

DEEPEST TEST:

Well: Discovery well, Depth: 11,854'. Formation: Vicksburg.

GRAVITY OF OIL: 29°-44° oil; 49°-55° condensate.

NUMBER OF PRODUCTIVE WELLS (Jan. 1, 1948): Oil: 67, Gas: 1, Condensate: 3. Total: 71.

METHOD OF PRORATION: 50% acreage, 50% per well; Spacing: 30 acres. Permitted GOR: 2,000-1.

DAILY FIELD ALLOWABLE (Jan. 1, 1948): 5,861 bbls. Average per well: 87 bbls.

OUTLETS: Texas P.L. Co.

LEADING OPERATORS: Humble O&R Co., Skelly Oil Co., Sun Oil Co., Superior Oil Co.

ESTIMATE ULTIMATE RECOVERY: 20 million bbls. Source: Oil & Gas Journal (1/29/48).

REMARKS: Includes "Ashwood" field (or "North Sugar Valley") & "South Sugar Valley," once called "East Van Vleck."

PRODUCTION RECORD:

YEAR	OIL		CONDENSATE	
	PRODUCTION (BBLs.)	CUMULATIVE	PRODUCTION (BBLs.)	CUMULATIVE
1943			926	926
1944			1,608	2,534
1945			1,363	3,897
1946	274,187	274,187	20,399	24,296
1947	1,407,896	1,742,083	18,532	42,828

GAS		CUMULATIVE
PRODUCTION (MCF)		
8,774		8,774
78,830		87,604
70,942		158,546
1,281,735		1,440,281
1,287,347		2,727,628

In addition to the statistical information on each field, a district field map, a county map for each county, and thirty field development maps are distributed through the text.

As stated by the author, the objective in gathering material for *Texas Gulf Coast Oil* was the compilation in one volume of data from various sources concerning all the commercially productive oil and gas fields in the area. In a publication of this type it was, of course, impossible to include detailed subsurface geological information for the individual fields.

The field development maps, particularly those with a type electric log bearing the field names for the various productive sands, such as the one reproduced on the Sugar Valley field map, and similar logs on several other field maps, are especially instructive to geologists unfamiliar with these fields.

Unfortunately, some of the maps have been reduced (maximum 7×10 inches) to such an extent that legibility has been considerably impaired. However, well completion figures and other fine printing on the field maps may be read with the aid of a reading glass, as may the finer print on all but a few of the county maps.

Material used in this work has been taken from reliable sources and it is well edited. The volume is adequately indexed and the printing, in the text, is clear and easily read.

The reviewer believes that this volume will be a valuable addition to the libraries of many geologists, as an up-to-date source of an immense amount of condensed statistical information, and an important historical record for the future, on the oil fields of the Upper Gulf Coast of Texas.

STATISTICS OF OIL AND GAS DEVELOPMENT AND PRODUCTION,
BY A.I.M.E. PETROLEUM DIVISIONREVIEW BY W. A. VER WIEBE¹

Wichita, Kansas

Statistics of Oil and Gas Development and Production (Covering the year 1947). Published by the American Institute of Mining and Metallurgical Engineers (October, 1948). 514 pp. For sale at the headquarters of the Institute, 29 West 39th Street, New York, 18, N. Y., or at the office of the Division secretary, 601 Continental Building, Dallas 1, Texas. Price, \$6.00.

The annual review of oil and gas developments in the world which is published by the Institute has now become a standard reference book. The excellent planning which goes into the compilation of tables and other types of statistical matter is shown in the present edition. Very little has been omitted by the planners and, if every contributor would send in the material called for, the reader would find nearly anything he might desire in the way of oil-field information.

In the present edition several items stand out. One of these is the great number and the wide distribution of deep tests. Another is the very wide application of repressuring methods. The third item which impresses the reader is the fact that our reserves are holding up remarkably well.

The state of Alabama still has only one oil field, but this one has now produced over a million barrels. In Arkansas water injection and gas injection are being tried on a very comprehensive scale and with good results. One of the pools in this state, the Village pool, now has 9 different producing zones in the Hosston formation. In California the most important development was the discovery of Eocene production in the large Kettleman Hills pool at a depth of more than 12,000 feet. In this state gas injection for pressure maintenance is gradually increasing, but water injection is still in its infancy. During October, 1947, the gas pipeline from Texas was put into operation. In Florida 27 wildcat tests were drilled during 1947, but all were dry. Several were very deep holes. The only producing field, Sunniland, produced more than $\frac{1}{4}$ million barrels of oil.

In Kentucky many deep tests were drilled. As a consequence, the first commercial oil from the Knox dolomite can now be put on record. In addition, commercial gas was also found in the St. Peter sandstone which heretofore had been dry in all tests. The most interesting development in Louisiana was the first finding of oil in the Gulf of Mexico, some distance from *terra firma*. In Michigan operators finally succeeded in proving the famous Howell scarpcline. One good-sized gas pool was found on it. The producing zone is in the Salina formation. In Mississippi five additional salt domes were found during the year under review. Deep drilling uncovered oil in the Lower Cretaceous rocks. In New Mexico the most interesting development was the finding of deep oil in the Dakota formation at Kutz Canyon (6,745 feet).

In New York many of the old Medina pools and some of the newer Oriskany pools are now completely exhausted. They are therefore being used for storage purposes. Gas from Texas is being stored for use during periods of peak-load conditions. In Oklahoma a record was set when the Superior Oil Company completed a deep hole in Caddo County at the total depth of 17,823 feet. A very interesting chapter on the Pacific Northwest is new in this edition. It covers Washington and Oregon and tells the location of seeps and gas mounds. The two maps showing the location of exploratory tests so far drilled will be found very useful. All important wells more than 2,000 feet deep are described. In addition, the author also describes the seismic exploration and the geological work which has been done up to date.

In Pennsylvania electric logs are now being used in water-flooding projects. Core studies are being carried on with a refinement and precision heretofore unknown. One new

¹ Professor of geology, University of Wichita. Review received, October 12, 1948.

Medina gas pool was found 5 miles northwest of Corry. In the Rocky Mountain states, which are treated as a unit, 23 wildcats were drilled in Utah. In Montana oil was found in the Kibbey formation at Ragged Point. This is a new producing zone in the state as well as a new structure proved for production.

In North Texas no less than 128 deep tests to the Ordovician Ellenburger were drilled. In 18 of these oil was found. West Texas shipped its first gas to California during October, 1947. In West Texas also the use of diamond-drill cores is expanding notably. Apparently they can compete here with other types of coring on a commercial basis. In Tennessee one deep test to pre-Cambrian rocks showed the Knox to have a thickness of almost 5,000 feet.

In West Virginia routine operations are described but the author steps over into southwestern Virginia to give a very full and complete description of the interesting Rose Hill pool which is located on an overthrust plate. On page 447 the reader will find a very interesting summary of all the drilling which has been done so far along the Atlantic Coastal Plain. The two deep holes drilled in North Carolina furnish some very important stratigraphic data.

The book ends with some reports on foreign fields. These reports are for the most part tantalizingly short and in many cases unsatisfactory. Nevertheless, half a loaf is better than none and the reader will be very grateful to the Institute for even these short contributions. In a future edition it might be worth while to ask each contributor to send in a short sketch on the stratigraphy or possibly a pictorial columnar section. For Austria there is a very good map which shows all the oil fields so far discovered and also a complete summary of drilling and production from 1930 to date. There is also a nice map to show the oil fields of Poland. For South America the reader will find rather complete reports for Peru and for Venezuela. The map showing the oil pools in Venezuela will be appreciated.

NEW LIST OF MAP SYMBOLS, BY UNITED STATES GEOLOGICAL SURVEY

REVIEW BY C. L. MOODY¹

Shreveport, Louisiana

"New List of Map Symbols," prepared by Map Symbol Committee, E. N. Goddard, chairman. *U. S. Geol. Survey Spec. Pub.* (1948). 6 sheets. Free on application to Director, Geological Survey, Washington 25, D. C.

The United States Geological Survey has recently issued a pamphlet, "New List of Map Symbols," which embodies the results of the labors of a map symbol committee composed of Ernst Cloos, Lewis B. Pusey, W. W. Rubey, and E. N. Goddard, chairman. It is stated in the pamphlet that the list of symbols "has been prepared primarily for use in the publications of the U. S. Geological Survey," but "it is hoped that it will be helpful to all geologists and will eventually bring about a general uniformity of usage."

The pamphlet portrays preferred symbols for contacts, faults, folds, bedding, foliation and cleavage, lineations, joints, mineral deposits, mine workings, surface openings, and underground workings, as well as conventional representation in sections of the various types and conditions of the faults.

Although economic geologists directly concerned with solid mineral products will find the new list of map symbols more immediately applicable in their work than will those engaged in the oil and gas industry, both groups are concerned with the problems inherent in representing on paper by simple means the complexities observed in nature. The work of the map symbol committee is designed to facilitate the solution of such problems. Prospective contributors to the *Bulletin* are urged to consult the pamphlet before designing maps to illustrate their articles.

¹ The Ohio Oil Company.

RECENT PUBLICATIONS

ALBERTA AND SASKATCHEWAN

"The Lower Cretaceous of the Lloydminster Oil and Gas Area, Alberta and Saskatchewan," by R. T. D. Wickenden. *Geol. Survey Canada Paper 48-21* (Ottawa, Canada, November, 1948). Text, map, figure.

BELGIAN CONGO

* "Les formations glaciaires et postglaciaires fossilifères, d'âge permocarbonifère (Karoo inférieur) de la Région de Walikale (Kivu, Congo belge)" (Glacial and Post-Glacial Fossiliferous Formations of the Permo-Carboniferous-Lower Karoo—in the Region of Walikale, Kivu, Belgian Congo), by Nicholas Boutakoff. *Mem. Inst. Geol. Univ. Louvain*, Vol. IX (1948). 122 pp., 5 pls. Approx. 9×12 inches. Paper cover. In French. This is Part II of Scientific Results of Geologic Mission of National Committee on Kivu, by A. Salée, N. Boutakoff, and J. de la Vallée Poussin. Institut Géologique de L' Université, 10, Rue St. Michel, Louvain, Belgium.

CALIFORNIA

* "Tidelands Pools of Huntington Beach Oil Field," by Eugene R. Murray-Aaron. *California Oil Fields*, Vol. 33, No. 1, San Francisco, January-June, 1947 (October, 1948), pp. 3-10; 6 pls., 1 chart.

* "Geology of the Tesla Quadrangle, California," by Arthur S. Huey. *California Div. Mines Bull. 140* (San Francisco, July, 1948). 75 pp., 3 figs., 11 pls.

CANADA

"Miscellaneous Classes of Fossils, Ottawa Formations, Ottawa-St. Lawrence Valley, Ontario," by Alice E. Wilson. *Canada Geol. Survey Bull. 11* (Ottawa, September, 1948).

CHINA

* *Journal of the Chinese Geophysical Society*, Vol. 1, No. 1 (Nanking, June, 1948). 100 pp., illus. First issue. Business communications should be addressed to Parker C. Chen, Institute of Meteorology, Academia Sinica, Pei-Chi-ko, Nanking, China. Price, U. S. \$0.50.

CZECHOSLOVAKIA

* "Numulitidae et orbitoidae de l'éocène de Bojnica-les-Bains près de Prievidza, Karpathes Slovaques," by Maria de Cizancourt. *Státný Geologický Ústav* (Geological Survey), Vol. 17 (1948), pp. 41-54, Pls. VI-IX, Fig. 1. In French. M. Kuthan, director, Geological Survey, Bratislava, Palisády 46, Czechoslovakia.

EASTERN MEDITERRANEAN

* "La tectonique profonde de la Syrie et du Liban," by H. de Cizancourt. Geological interpretation of gravimetric measurements. *Notes et Mémoires*, Tome IV (Beyrouth, June, 1948), pp. 157-90; 16 figs. In French. Published under the direction of M. Louis Dubertret, mining engineer, Beyrouth, Lebanon.

FRANCE

* "Le bassin tertiaire de Saint-Martin de Londres et l'orogénèse de l'anticlinal du pic Saint-Loup (Hérault)," by M. Dreyfuss and M. Gottis. *Bull. Soc. Geol. France*, Vol. 17 (1947), Ser. 5, Nos. 4-5-6 (May, 1948), pp. 293-300; 4 figs.

GENERAL

* *Oil and Gas Field Development in United States, 1947*, by National Oil Scouts and

Landmen's Association, Austin, Texas. Year Book 1948 (Review of 1947), Vol. 18. 897 pp. 7.75×10.50 inches. Cloth. Price, \$8.50.

* *Oil and Petroleum Year Book, 1948*, compiled by Walter E. Skinner. International standard reference book on the world oil industry. 400 pp., 5.25×8 inches. Up-to-date particulars about 660 companies, producers, refiners, transporters, finance and oil dealers, arranged alphabetically, American and foreign companies included. Walter E. Skinner, 20, Copthall Avenue, London, E. C. 2. Price, \$4.00, post-free abroad.

Historical Geology, by Carl O. Dunbar. Successor to *Outlines of Historical Geology*, by Charles Schuchert and Carl O. Dunbar. Approx. 500 pp. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. 1st ed., January, 1949. Price, probably \$5.00.

* *Physical Geology*, 3d ed. (1948), by Chester R. Longwell, Adolph Knopf, and Richard F. Flint. 602 pp., 365 figs. 6×9 inches. Cloth. Illus. paper jacket. "An introduction to geology, with emphasis on principles rather than bare facts. The treatment is simple, designed to meet the needs of a person with no knowledge of geology." John Wiley and Sons, Inc. Price, \$5.00.

"Report of the Committee on a Treatise on Marine Ecology and Paleocology, 1946-1947," by Harry S. Ladd, Kenneth E. Lohman, et al. *National Research Council Division of Geology and Geography*, No. 7 (Washington, D. C., 1948). 93 pp. Mimeog. Price, \$1.00.

"Petroleum Development and Technology, 1948," *Trans. Amer. Inst. Min. Met. Eng.* (Petroleum Division), Vol. 174 (1948). 340 pp. Papers and discussions presented before the Division at meetings held at Galveston, Oct. 3-5, 1946; Los Angeles, Oct. 24-25, 1946; Oct. 23-24, 1947; New York, March 19-22, 1947; Denver, Sept. 28-Oct. 2, 1947; and Tulsa, Oct. 8-10, 1947.

* *Summarized Proceedings and Directory of Members of the American Association for the Advancement of Science*. 1219 pp. Includes a brief history of the A.A.S. from its founding in 1880 to 1948, and its present organization and operation. Published by A.A.S., 1515 Massachusetts Avenue, NW., Washington 5, D. C. Price, cloth, \$9.50.

Rotary Drilling Handbook, by J. E. Brantly. 4th ed. (1948). 560 pp., 200 pp. of tables and formulas. Published by Petroleum World, 412 West 6th Street, Los Angeles, California. Price, \$7.50.

Submarine Geology, by Francis Parker Shepard. 338 pp., illus. Harper's Geoscience Series, edited by Carey Croneis. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price, \$6.00.

* "The Application of Geophysics to Geology," by J. M. Bruckshaw. *Proc. Geologists' Association*, Vol. 59, Pt. 3 (London, September 30, 1948), pp. 113-30; 11 figs. Complete September issue available from Benham and Company, Ltd., High Street, London. Price, 5/-.

* "Propagation of Sound in the Ocean." *Geol. Soc. America Mem.* 27 (New York, October 15, 1948). Contains 3 articles.

"Explosion Sounds in Shallow Water," by J. Lamar Worzel and Maurice Ewing. 53 pp., 19 figs., 7 pls.

"Theory of Propagation of Explosive Sound in Shallow Water," by C. L. Pekeris. 117 pp., 51 figs., 9 pls.

"Long-Range Sound Transmission," by Maurice Ewing and J. Lamar Worzel. 35 pp., 19 figs. 4 pls.

* "On Lineation and Petrofabric Structure, and the Shearing Movement by Which They Have Been Produced," by Ernest Masson Anderson. *Quar. Jour. Geol. Soc. London*, Vol. 104, Pt. 1 (August 31, 1948), pp. 99-132; 10 figs. Longmans, Green and Company, Ltd., 6-7 Clifford Street, London, W. 1. Price of complete journal, 10 shillings.

* "Bibliographie des Sciences Géologiques" (Bibliography of Geological Sciences). Published by Société Géologique de France with cooperation of the Société Française de Minéralogie. Vol. 18, Ser. 2, 1947 (1948). Lists publications received in Paris during 1947.

430 pp., 6.5 × 10 inches. Paper cover. Société Géologique de France, 28 rue Serpente VI, Paris.

* *Tulsa Geological Society Digest*, Vol. 16 (1948). 138 pp., including advertising. Published annually by the Society, containing principally the abstracts of paper on the Society programs from October, 1947, to June, 1948. Edited by Robert F. Walters. For further information address the secretary, Noel Evans, 1610 Philtower Building, Tulsa, Oklahoma.

General Cartography, 2d ed. (1948), by Erwin Raisz. 354 pp., 299 figs. 7.25 × 9.75 inches. McGraw-Hill Book Company, Inc., New York. Cloth. Price, \$6.00.

* "The Nature and Origin of Limestone Porosity," by Richard B. Hohl. *Quar. Colorado School Mines*, Vol. 43, No. 4 (Golden, October, 1948). 51 pp., 20 figs. Price, \$1.00.

* *Antitrust Laws et al., v. Unit Operation of Oil or Gas Pools*, by Robert E. Hardwicke. 300 pp. 5.5 × 8.25 inches. Published by Amer. Inst. Min. Met. Engineers (with cooperation of Cities Service Company), 29 West 30th Street, New York 18, N. Y. Price, \$1.50.

* "Entstehung des Erdöls" (Origin of Petroleum), by Alfred Treibs. *Erdöl und Kohle*, Vol. 1, No. 4-5 (Hamburg, 1948), pp. 137-43 (to be continued). Published by Industrieverlag von Hernhausen K. G., Hamburg 36.

* *Physical Geology and Man*, by Kenneth K. Landes. 414 pp., 164 figs., 6 × 9 inches. "This book is designed especially for students enrolled in the first term of a two-term course in Physical and Historical Geology." Prentice-Hall Geology Series, Norman E. A. Hinds, editor. Prentice-Hall, Inc., 70 Fifth Avenue, New York (1948). Price, cloth, \$6.00.

* *Geology and Man*, by Kenneth K. Landes and Russell C. Hussey. 518 pp., 188 figs. 6 × 9 inches. "... designed for a one-term course which may be both a beginning and a terminal course in geology." *Ibid.* Price, \$6.45.

* "Vertical Air Photographs as a Geological Tool," by N. L. Falcon. *Inst. Petrol. Review*, Vol. 2, No. 22 (London, October, 1948), pp. 289-94; 5 figs. Institute of Petroleum, 26 Portland Place, London, W. 1. Price 2s.

Geophysical Case Histories, Vol. 1 (1948). A collection of 60 papers by 61 authors on geophysical observations made under a wide variety of field circumstances. Edited by L. L. Nettleton. 680 pp., illus. 7 × 10 inches. Society of Exploration Geophysicists, Box 1614, Tulsa, Oklahoma. Price, clothbound, \$7.00, postpaid.

GERMANY

* "Mikropaläontologische Untersuchungen zur Stratigraphie des westfälischen produktiven Oberkarbons" (Micropaleontological Research in the Stratigraphy of the Producing Upper Carboniferous of Westphalia), by Helmut Bartenstein. *Erdöl und Kohle*, Vol. 1, No. 4-5 (Hamburg, 1948), pp. 143-45; 1 chart.

IRAN

* "Notes on the Geology of the Elburz Mountains, North-East of Tehran, Iran," by Edward Battersby Bailey and Robert Cyril Briscoe Jones. *Quar. Jour. Soc. London*, Vol. 104, Pt. 1 (August 31, 1948), pp. 1-42; 9 figs., 2 pls. (maps), Longmans, Green and Company, Ltd., 6-7 Clifford Street, London, W. 1. Price of complete journal, 10 shillings.

JUGOSLAVIA

* "Sur le delta du Danube dans le region de Kladovo-Turnu Severin-Sip" (The Delta of the Danube in the Region of Kladovo-Turnu Severin-Sip), by K. V. Petković. *Bull. Soc. Serbe Géographie*, Tome 27, No. 1 (1948), pp. 1-19; 5 figs. Pp. 16-19, résumé in French. Contains several well profiles. Address: Société Serbe de Géographie, Belgrade, Studentski Trg., 3, Jugoslavia.

* "LaVallee de la Tisa en Yougoslavie" (Tisa Valley in Yugoslavia), by Branislav Bukurov. *Editions Speciales de la Soc. Serbe de Geographie*, Fascicule 25 (Belgrade, 1948). 54 pp., 10 figs. Pp. 50-52, résumé in French.

KANSAS

* "Ground-Water Resources of Republic County and Northern Cloud County, Kansas," by V. C. Fishel. *Kansas Geol. Survey Bull.* 73 (Lawrence, May, 1948). 194 pp., 12 pls., 6 figs., 22 tables.

MISSISSIPPI

* "Petroleum Potentialities of North Mississippi," by William Clifford Morse. *Oil Newsmagazine*, Vol. 8, No. 7 (New Orleans, Louisiana, September, 1948), p. 11.

NETHERLANDS

* "Symposium on Phenomena of Rock Pressure in Coal Mining." *Geologie en Mijnbouw*, Vol. 10, New Ser., No. 19 (Sparne 17, Haarlem, October, 1948), pp. 193-292, illus. In Dutch, French, English.

TENNESSEE

* "The Geology of West Tennessee," by Clifton M. Keeler. *Oil Newsmagazine*, Vol. 8, No. 9 (New Orleans, Louisiana, November, 1948), pp. 19-23, 28; 4 figs.

UTAH

* "Geology of the Paleozoic Rocks, Logan Quadrangle, Utah," by J. Stewart Williams. *Bull. Geol. Soc. America*, Vol. 59, No. 11 (New York, November, 1948), pp. 1121-64; 6 pls., 2 figs.

WYOMING

* "Geology and Petroleum Resources of Wyoming," by Horace D. Thomas. *Petrol. Eng.*, Vol. 20, No. 2 (Dallas, Texas, November, 1948), pp. 128-38; 3 figs.

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A.—Pittsburgh regional meeting, technical session in Urban room, William Penn Hotel.



B.—Pittsburgh Geological Society officers and committee chairmen: S. S. Philbrick, U. S. Army Engineers, arrangements; J. C. Patton, Equitable Gas Company, secretary; W. B. Robinson, Gulf Research and Development Company, vice-president; John T. Galey, independent operator, president; George C. Grow, Jr., Peoples Natural Gas Company, field trips; S. Galpin, Peoples Natural Gas Company, treasurer; H. R. Brankstone, Gulf Oil Corporation, general chairman.

PITTSBURGH MID-YEAR MEETING, OCTOBER 4-9, 1948

W. B. ROBINSON¹

Pittsburgh, Pennsylvania

The mid-year meeting held in Pittsburgh, Pennsylvania, October 4 to 9, 1948, provided an excellent opportunity for A. A. P. G. members to study the geology of the northern Appalachian area. Nearly 300 attended the meetings.

The two-day technical sessions held in the William Penn Hotel were capably opened with a review of Appalachian geology by R. E. Sherrill. Abstracts of several of the papers appeared in the November *Bulletin*. The presiding officers for the four half-day sessions were: John T. Galey, George C. Grow, Jr., R. E. Somers, and W. B. Robinson. All of the twenty technical papers dealt with Appalachian geology, excepting one which described an aerial magnetometer survey of the Appalachian Plateau in central Pennsylvania.

Guest speaker at the banquet Monday evening was E. R. Weidlein. His talk on "The Philosophy of Research" was made doubly interesting by relating the accomplishments of many research projects.

We regret to announce that the author of one paper, James Fulton Swain, was killed in an airplane crash as he was returning to Pittsburgh for the meeting. His paper, "Geology and Occurrence of Oil in the Medina Sand of the Blue Rock-Salt Creek Pool, Ohio," was to have been given Tuesday morning. The crash occurred Monday evening. Swain had been a member of the A. A. P. G. since 1942 and was employed by the firm of Huntley and Huntley, consulting geologists. He was respected and admired by many friends for the high caliber of his work.

The field trip was attended by 97 geologists who rode in three chartered Greyhound buses. A police escort assisted the convoy in getting through the larger towns. The first day of the trip traversed the section from west to east between Pittsburgh and Harrisburg. This covered the geologic section from younger rocks to older. Six stops were made to examine exposures of Paleozoic rocks ranging from Pennsylvanian age to Cambrian age, inclusive. Skies were overcast when the caravan reached the Allegheny Front, otherwise an excellent view of the Ridge and Valley Province would have been seen. Frank M. Swartz very capably described the structural features at each of the stops in Pennsylvania and outlined important sedimentary changes through the area traversed. He made use of portable amplifier and large maps to illustrate his comments. John G. Broughton, W. F. Jenks, and Frank Swartz handled the discussions at stops in New York.

On the second day the caravan travelled north from Harrisburg to Rochester following up the course of the Susquehanna River, which is superposed upon the structural features of the area. In the afternoon many members of the party saw glacial topography for the first time. That evening a buffet supper was provided by the Bausch and Lomb Optical Company at the Rochester Museum. After the excellent meal the group visited the museum and, in addition to seeing many fine museum displays, saw the newest microscopes and other optical instruments made by Bausch and Lomb.

On the third day the trip skirted the southern shore of Lake Ontario near the escarpment capped by the Middle Silurian Lockport dolomite. Silurian and Ordovician beds were seen in gorges cut by the Genesee and Niagara rivers. The hour and a half walk up the Niagara Gorge was accomplished in a brisk downpour of rain. The last stop on the trip was at Bennett Quarry in Buffalo where the disconcerting disappearance of Oriskany and associated strata was discussed. The field trip ended at Buffalo.

Fifty-eight members of the field trip went on to Bradford, Pennsylvania, to observe the water-flooding operations in the Bradford field. Maynard M. Stephens gave an interesting and informative talk on "The Geologic Factors Involved in Secondary Recovery." Visits were made to the Penn Grade Research laboratories and the laboratories of the

¹ Gulf Research and Development Company.



1.—At the reception given by president Miguel Aleman of Mexico. Left to right: Douglas Weatherston, chairman, general committee for the field trip; Jorge L. Cumming, assistant chief of exploration for Pemex; Manuel Rodriguez Aguilar, chief of exploration, Pemex; Senator Antonio J. Bermudez, director of Pemex; President Aleman; Marion J. Moore, president, South Texas Section; Ezequiel Ordóñez, long known as an authority in Mexican geology; and Guillermo P. Salas, chief geologist for Pemex.



2.—Group representing Mexican geologists in arrangements for the Mexico City meeting and field trip: front, Federico Mina; Sara Batiza; Jorge L. Cumming; Guillermo P. Salas; James W. Thomas, Geophysical Service, Inc. Back, Benjamin F. Rummerfeld, Westby Geophysical Corporation; Alfonso Villasenor; Antonio Garcia Rijas; Manuel Alvarez, Jr. All excepting Thomas and Rummerfeld are with Pemex.

Ryder-Scott Company. The group had lunch at the Valley Hunt Club as guests of several local companies.

The buses returned to Pittsburgh about 7:00 P.M. At that point the geologists from 17 states pronounced the mid-year meeting a huge success, bade farewell to acquaintances both new and old, and hurried off into the city's noisy darkness—homeward bound.

SOUTH TEXAS SECTION 15TH ANNUAL MEETING, MEXICO CITY OCTOBER 18-23, 1948

The Hotel del Prado, Mexico City, was the convention headquarters of the 15th A.A.P.G. South Texas Section annual meeting on October 18-23. The meeting, held in Mexico at the invitation of Petroleos Mexicanos, was attended by 150 geologists, their wives, and friends. The technical sessions were in the Palacio de Bellas Artes, where Senator Antonio J. Bermudez gave the address of welcome. President Miguel Aleman of Mexico gave a reception in his office at the Castle of Chapultepec in honor of the geologists and their wives. Petroleos Mexicanos entertained with a cocktail party and a dinner-dance, both at the Hotel del Prado. Each registrant at the meeting was presented with a copy of the book, *El Volcano Paricutin*, by honorary member Ezequiel Ordonez. Field trips were taken to the Poza Rica oil field and Paricutin Volcano.

OFFICERS OF SOUTH TEXAS SECTION

President: Marion J. Moore
Vice-Pres: Paul B. Hinyard

Secy.-Treas.: Maurice E. Forney
Past-Pres.: Guy E. Green

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General: Douglas Weatherston, Jorge L. Cumming, Robert N. Kolm
Technical Program: William H. Spice, Jr., Guillermo P. Salas
Hotels: Alfonso Villasenor, W. L. Stapp
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Entertainment: Federico Mina, C. A. Daubert, James W. Thomas
Field trips: Manuel Alvarez, J. B. Souther
Public relations: Leland L. Palmer
Exhibits: R. S. Mann, Alfonso Villasenor
Reception and registration: Van A. Petty, Jr., Srita. Sarah Batiza, Ben Rummerfield
Transportation: R. D. Mebane, Antonio Garcia Rojas

ABSTRACTS

1. Tectonics of Republic of Mexico, Manuel Alvarez, Jr., geologist, Petroleos Mexicanos.

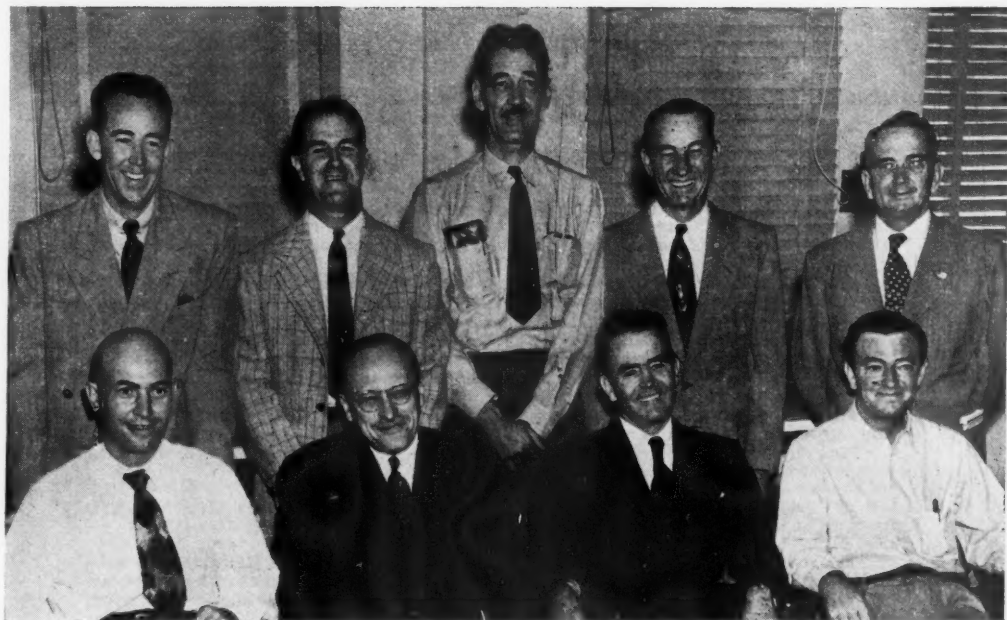
It has been attempted to give in this paper, for the first time, an idea of the tectonics of the Republic of Mexico as a whole, based on the concepts developed, mainly by alpine geologists, for the study of orogenic processes.

With this object in view, the paper was divided in two parts; the first, in which was established the meaning of the concepts in order to fix the sense in which they will be used and to point out in a general way the orogenic processes to which the Republic of Mexico was subjected. The second part in which are described the major structural units, from a tectonic point of view, especially as to the character and orientation of their folds, since the character of the major units is mainly established from the character of the folds.

There have been established in the foreland of the Mexican geosyncline, three shelves, a large massif, two small ones, and four basins. There have been postulated for the hinterland a great massif or continent, two large massifs, two medium, and four small massifs as well as three basins. The foredeep of the geosynclinal folds has been indicated in three regions, as established by the "flysch" sediments deposited therein.

It is considered that the geosynclinal folds of the Mexican Cordillera begin west of Ciudad Juarez toward Torreon, where they turn toward Monterey, and from there, southeast down to the Coatzacoalcos River, then northwest up to the Chalchijapa River and on reaching the narrowest part of the Isthmus of Tehuantepec they turn east-southeast into Guatemala.

It is established that the orogeny which gave rise to this folding started at the end of the Cretaceous in the northern part of the Republic and at the beginning of the Eocene in the rest of the country, and ended at the end of the Eocene except in the southeast where it lasted until the begin-



3.—These men made the arrangements for the South Texas Section: front, Robert S. Mann, exhibits; Robert N. Kolm, general committee; Douglas Weatherston, general committee; Van A. Petty, Jr., reception and registration; back, R. D. Mebane, transportation; Leland L. Palmer, public relations; William H. Spice, Jr., technical program; Charles A. Daubert, entertainment; and George H. Coates, finance. Not shown are Wilford L. Stapp, hotels and housing, and J. B. Souther, field trips.



4.—Officers of South Texas A.A.P.G. Section: right, Paul B. Hinyard, Shell Oil Company, Inc., vice-president; Marion J. Moore, Sunray Oil Company, president; and Maurice E. Forney, Atlantic Refining Company, secretary-treasurer.

ning of the Oligocene. Furthermore, there were previous and posthumous movements, the last of which is very important in the Isthmus and in the Macuspana and Pichucalco basins.

2. Short Discussion of Mexican Oil Fields, Antonio Garcia Rojas, chief geophysicist, Petroleos Mexicanos.

Mexico's oil production comes from three main provinces which according to their importance could be arranged as follows:

- (1) Northern zone (Tampico-Tuxpan oil fields), (2) Southern zone (Isthmus, Saline Basin), and (3) Northeastern Mexico.

Most of the production of the Tampico-Tuxpan oil fields comes from the Tamaulipas limestone, Cretaceous in age, and which has a wide variation of facies. The total production from these fields has amounted to 2,160 million barrels, divided in three main producing areas: Faja de Oro (Golden Lane), Panuco-Ebano, and Poza Rica.

The Isthmus oil fields produce from Miocene sands and a very small production has been obtained from cap rocks. All producing structures in the Isthmus areas are related to salt domes. The total production obtained from these fields is about 140 million barrels.

No commercial production has been found until recently in northeastern Mexico, but some gas fields have been in production for several years.

Pemex has discovered recently the Reynosa field, which has two producing oil wells with a capacity of about 1,100 barrels per day for both wells.

3. Geology and Development of Poza Rica Field, State of Vera Cruz, Mexico, Ing. G. P. Salas, chief geologist, Petroleos Mexicanos.

The Poza Rica field is the most important and largest producing field in Mexico. It lies on the Gulf Coastal Plain approximately at 160 kms. south-southwest of Tampico and at 175 kms. northeast of Mexico City. The structure was found originally by geophysics through an almost simultaneous torsion balance and refraction shooting survey. Poza Rica No. 2 well, completed on May 2, 1930, as a gas producer, discovered a subsurface trap drilling in the gas cap in a porous Tamabra limestone at -2,047.3 meters (-6,715 feet).

Further deepening of the well brought it in as an oil producer. It was later shut in, because of high gas-oil ratio, in 1933.

Later reflection shooting revealed possible extensions and permitted development program. First exploration wells were located at distances between 600 and 1,000 meters (1,968 and 3,281 feet).

Completion of wells was first accomplished through 4½-inch liner. Later wells produced through 2½-inch tubing.

There are at present 93 wells of which only 4 were dry through lack of porosity in the limestone. Seventy-eight are producing at present. The structure at Poza Rica, as revealed from both seismos and subsurface geology, is a broad anticline in a Tamabra limestone which is open, as yet, toward the west northwest. The highest well, Poza Rica No. 65, found the limestone at -1,947 meters (6,386 feet). The lowest producing well, Escolin No. 2, found the limestone still porous at -2,178 meters (-7,144 feet). Apparently the porous producing zone is due to a reef facies deposited on the highest part of a Cretaceous limestone anticline. Later regional tilting, and subsequent folding apparently displaced the porous zone toward the northeast flank, so that at present no porosity has been found on the south flank. Poza Rica No. 8 and No. 46 are the southernmost wells drilled to the limestone without finding it porous.

This field has produced 50,380,902 M³ (316,895,800 barrels) since 1930, and is considered to have a potential reserve of 143,169,000 M³ (900,533,000 barrels).

4. New Petroleum Development by Pemex in Northeastern Mexico, Eduardo J. Guzman, geologist, Petroleos Mexicanos.

A brief outline is given of the geological, geophysical and drilling explorations done by Petroleos Mexicanos in northeastern Mexico. The area under consideration is stratigraphically and structurally part of the geologic province commonly designated as the Coastal Plain or Gulf Coast of Texas and Louisiana.

The subsurface stratigraphic sequence and descriptions as given are used for identification purposes by Petroleos Mexicanos without attempting any revision on age or correlation of these formations.

A summary is given of the criteria used in the correlation of the well sections with the corresponding sections in other wells. The writer describes briefly the structures drilled or being drilled by Petroleos Mexicanos near the border, presents their seismological maps and cross sections and gives tentative correlations with wells on the American side.

Production and completion data of such wells are also given.

5. The Activity of Paricutin Volcano,* Ray E. Wilcox, United States Geological Survey.

During the 5½ years since its birth Paricutin Volcano has been constantly active, with lava issuing at a remarkably uniform rate and ash and bombs somewhat less uniformly. In the first two years the dense ash eruptions destroyed many thousands of acres of crops, pastures, and forests in the area near the volcano, while ash-laden flood waters caused damage well outside the immediate area. During the past three years the less continuous ash eruptions have permitted a limited agricultural and biological recovery in the marginal zones, although some processes, such as erosion, continue almost unchecked.

The current investigation of the geochemical activity and eruptive behavior of Paricutin and of the petrology of its ash deposits and lava flows is for the purpose of adding to our knowledge of the poorly understood processes of volcanic eruptions and ore formation. Because the volcano area is itself a giant natural laboratory, it has been the object of a variety of studies—some of them of a continuous nature—not only in geology and geophysics, but also in biology, geography, agriculture, and other natural sciences.

6. Geology of Gulf Coastal Area and Continental Shelf, J. Ben Carsey, geologist, Humble Oil and Refining Company.

A coastal plain varying in width up to 100 miles borders the Gulf of Mexico in the southern portion of the United States. This plain is tilted 5 feet per mile toward the Gulf. This almost imperceptible slope extends out into the open water where the gradient is 8-12 feet per mile on top of the continental shelf, but steepens to 400-600 feet per mile off the edge of the shelf. This change in slope occurs at the 100-fathom line. The shelf is 50 miles wide south of Mobile Bay and 70 miles wide at the mouth of the Rio Grande, but reaches a maximum width of 150 miles between these points south of the Sabine River.

Several hundred salt domes have been discovered on the coastal plain, and domes have already been located by geophysical work in the open water. More than 140 dome-like topographic prominences with relief varying from 12 feet to 600 feet are present along the edge of the shelf.

The Mississippi River is building its delta across the shelf at the rate of one mile in 16 or 17 years and is now within 12 or 15 miles of the edge of the shelf. The natural levee along the Mississippi serves as a ramp from which oil operations have taken place, and ten or more domes are now producing from this ramp. These domes are well out on the shelf, thus there is actually nothing new about oil production from the shelf area.

7. Marine Exploration in Gulf of Mexico, C. T. Jones, manager, foreign exploration department, and Shirley T. Mason, senior geologist, Texas-Louisiana Gulf Coast division, Stanolind Oil and Gas Company.

Marine exploration is one of the most expensive types of development ever undertaken by oil companies; the great amount of capital which must be hazarded before any returns are assured, necessarily restricts these operations to the larger companies. To meet this enormous cost, some of the large companies, which otherwise are unrelated, have combined for marine work. A complete exploration department of landmen, geologists, and geophysicists is required. Operations of these integrated departments must be coordinated continually without delay by an understanding management. The risks encountered in marine work are great. In addition to executive efficiency, proper management calls for daring in the use of capital and clear vision as to future values of resources now uncommercial.

Modern marine exploration for offshore oil and gas fields was apparently started experimentally in 1940, but had not reached its present large scale until 1946. The first offshore leases of the present type were obtained off the coast of Louisiana in 1945 and off Texas in 1947. Leasing requirements are different in Louisiana and Texas, and the more favorable conditions in Louisiana have resulted in the greater development there. The tidelands title controversy remains unsettled. Government agencies, such as the Corps of Engineers and the U. S. Coast Guard, demand that all of their regulations be respected. The fishing interests of Louisiana and Texas have made it difficult for the oil companies to plan and execute exploratory campaigns properly, thus increasing the cost. The high rentals paid for leases force early development.

All types of geophysical exploration have been utilized in the Gulf of Mexico campaign. Originally, the gravity meter was used by lowering it with an operator in a diving bell; later, the present remote-controlled gravity meter was evolved. Magnetic surveying, using both airborne and boat-towed instruments, is also employed. Early seismograph work, with charges and seismometers on the Gulf floor, was slow and costly. Experience has greatly refined seismic methods until, today, this

* Published by permission of the director of the United States Geological Survey.

type of exploration is rapid, economical and obtains excellent results. It is estimated that all of the offshore areas of Louisiana, out to the 10-fathom depth, and about half of those of Texas, along a similar belt, have been mapped to date.

The culmination of this marine exploration program began late in 1947 with the development of production on the first piercement-type salt dome at a comparatively shallow depth. To date, five additional discoveries have been made of either oil or gas fields, and tests on three other prospects are encouraging.

The great cost and risk of marine exploration work must be recognized as small in comparison with the expense and hazard of the later exploitation phase. The tremendous costs of this development, to say nothing of the losses incurred in the dry wildcat wells which have been drilled and will continue to be drilled, will only be justified if there are no restrictions to prevent reasonable profits on the successful operations. The results of offshore work to date tend to confirm the original anticipation that this risking of enormous quantities of private capital will eventually make a great addition to the oil and gas reserves of the Western Hemisphere.

8. Variations in History of Continental Shelves, Paul Weaver, president, American Association of Petroleum Geologists.

Some students think of shelves as hinge lines, with the land side uplifted and the sea side down-warped. The author discusses contrasting types of shelves which are more properly erosion features and not tectonic in origin, especially those in the region of the Gulf of Mexico.

9. Geology of Pacific Coast of Ecuador, Cecil Hagen, Hagen & Cantrell, consulting geologists.

The general geology of the Pacific Coast of Ecuador is described. The area is approximately 500 miles north and south, ranging from the Peruvian border on the south to the Colombian border on the north. The formations include Cretaceous, Tertiary, and Recent sediments. The coast is divided into three areas; Northern, Central, and Southern. An attempt is made to describe the structural and depositional conditions present in each area. The paper is illustrated by a general map, geologic maps, correlation charts, columnar sections, and cross sections.

POZA RICA OIL-FIELD TRIP

Leave at 7:30 A.M. from convention headquarters and drive in busses to the town of Tulancingo, stopping to see an outcrop of obsidian, then proceed to Huauhinango where lunch will be served, after observing some outcrops of Jurassic rocks on the road in the neighborhood of this town. From Huauhinango to Poza Rica, a fine section of outcrops ranging from Jurassic to Miocene age will be seen. After supper in Poza Rica, part of those on the trip will spend the night there and the rest will be accommodated in the neighboring town of Papantla.

On Friday, October 22, after breakfast in Poza Rica, the Poza Rica field and refinery will be observed and the trip will proceed to Tecolutla for lunch. After lunch, the trip will proceed to Nautla, and from there to Teziutlan, stopping on the way to see some outcrops of Tertiary and Jurassic formations. In Teziutlan dinner will be served, and hotel accommodations will be available.

On Saturday, October 23, after breakfast in Teziutlan, the trip will leave for Perote and Puebla, observing on the way some igneous and metamorphic phenomena.

At Puebla, the largest and most typical colonial city, lunch will be served and the afternoon will be spent visiting the main interesting points and the group will leave for Mexico City, where they will arrive at about 7:30 P.M.

We do not recommend that members drive their own automobiles on this field trip and, as proper accommodations are not easily available for a great number of persons in the Poza Rica-Papantla area, the number taking this trip will be limited to 40 persons.

PARICUTIN VOLCANO FIELD TRIP

Leave convention headquarters, Hotel del Prado, Thursday morning, October 21, visit Toluca, and stay overnight at San Jose Purua. The next night, October 22, will be at Uruapan which is the nearest town to the Volcano, returning to Mexico City the evening of October 23 after having lunch at Morelia.

The cost of this three day trip, which includes transportation, hotel, meals, etc., will be approximately \$46 per person.

Passenger cars available will accommodate a maximum of four persons and will be driven by a chauffeur-guide who will give necessary explanations to the passengers. Horses will be available so that anyone desiring to go close to Paricutin Volcano can make the trip on horseback.

Anyone having a personal car can make this trip over a good highway. But if you are arranging your own transportation, we suggest that hotel accommodations be obtained before leaving Mexico City. It would not be necessary to return to Mexico City as the return trip to the States can be made

on a good highway through Guadalajara, and San Luis Potosi, connecting with the Pan-American Highway at Antiguo Morelos.

PACIFIC SECTION 25TH ANNUAL MEETING, PASADENA,
OCTOBER 28-29, 1948

The 25th annual meeting of the Pacific Section of the Association was again held at the Huntington Hotel, Pasadena, California,—this year on October 28 and 29. Concurrent sessions of the Pacific Section of the Society of Economic Paleontologists and the Pacific Coast Section of the Society of Exploration Geophysicists made this a representative and well attended joint convention of the technical oil-exploration groups on the Pacific Coast. The total registration numbered 668, including 409 A.A.P.G. members and 259 guests (S.E.G. and S.E.P.M. members, and students). The A.A.P.G. executive committee was represented by president Paul Weaver of Houston, Texas, and vice-president Roy M. Barnes of Los Angeles, California. The annual luncheon, held on Thursday noon, was attended by 418 persons and the dinner-dance, on Friday night, was attended by 500 persons.

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Vice-Pres.: Harvey W. Lee	Past-Pres.: Martin Van Couvering
San Joaquin Valley Representative: Alfred W. Vitt	

COMMITTEES

Program: John E. Kilkenny, Russell R. Simonson, John D. Hale
Arrangements: Fred E. Vandenberg, Jack W. Knight, Wallace L. Matjasic
Publicity: Sam Stewart

SECTION OFFICERS ELECTED FOR 1949

President: Clifton W. Johnson, Richfield Oil Corporation, Los Angeles
Vice-President: John E. Kilkenny, Chanslor-Canfield Midway Oil Company, Los Angeles
Secretary-Treasurer: Harold E. Rader, Standard Oil Company of California, Los Angeles

S.E.P.M. SECTION OFFICERS ELECTED FOR 1949

President: Aden W. Hughes, Union Oil Company of California, Orcutt
Secretary-Treasurer: Ursel S. Armstrong, Shell Oil Company, Inc., Long Beach

S.E.G. SECTION OFFICERS ELECTED FOR 1949

President: Robert C. Dunlap, Geophysical Service, Inc., Bakersfield
Secretary-Treasurer: William D. Cortright, Tide Water Associated Oil Company, Bakersfield

ABSTRACTS

1. Geology of Santa Cruz Island, William Rand, Union Oil Company, Santa Barbara, Calif.

Stratigraphy structure and surface geology of the island are discussed. Major faulting has separated the area into distinctive lithologic and structural provinces with individual characteristics which are described. Comparison of the geology of Santa Cruz Island with other regions is made.

2. Recent Developments in Salinas Valley, R. R. Thorup, consultant, King City, Calif.

The discovery of oil in the upper Miocene by The Texas Company at San Ardo in November, 1947, culminated 47 years of unsuccessful exploration and 91 dry holes. In the ensuing ten months (to October, 1948) an additional 38 wells have been drilled. These include three discoveries, 19 producing wells, 15 dry holes and four wells currently drilling.

Most of the post-discovery exploration has been directed to the upper Miocene sands. Drilling is soon to be commenced in areas adjacent to the San Andreas fault and also west of the Salinas River for middle Miocene sand objectives.

Three different pools have been discovered, and oil sands recently encountered by the Cleveland Oil Company north of San Ardo indicate the probability of a fourth pool. Oil sands on both sides of the King City fault suggest that the time of original accumulation was pre-King City fault.



FIG. 1.—Newly elected officers of A.A.P.G. Pacific Section meet with retiring president. Left to right: Clifton W. Johnson, Richfield Oil Corporation, newly elected president; William P. Winham, Standard Oil Company of California, retiring president; John E. Kilkenny, Chanslor-Canfield Midway Oil Company, newly elected vice-president; Harold E. Rader, Standard Oil Company of California, newly elected secretary and treasurer.



FIG. 2.—Retiring officers of Pacific Section. Left to right: Peter H. Gardett, General Petroleum Corporation, secretary and treasurer; Harvey W. Lee, Union Oil Company, vice-president; William P. Winham, Standard Oil Company of California, president.



FIG. 3.—Committee responsible for 25th joint fall meeting. Left to right: Fred E. Vandenberg, Kern Oil Company, Ltd., general arrangements chairman; Jack W. Knight, British-American Oil Producing Company, dinner-dance chairman; Wallace E. Matjasic, Honolulu Oil Company, registration chairman; William P. Winham, Standard Oil Company of California, finance chairman and retiring president of Pacific Section; Peter H. Gardett, General Petroleum Corporation, retiring secretary and treasurer of Pacific Section.

Contours on top of the basement show a high basement area, nearly reaching the surface, extending south from San Lucas toward San Ardo on both sides of the Salinas River, and a steep basement slope along the present western edge of the Salinas Valley.

3. San Ardo Oil Field, Harry A. Campbell, Jergins Oil Company, Bakersfield, Calif.

The San Ardo oil field lies in and close to the foothills east of the Salinas River south of the town of San Ardo. The Lombardi pool lies at the north end of the field while the Campbell pool is at the south end. The Lombardi pool is limited by the dry holes on the north and east while the limits of the Campbell pool are not established at this date. The first well to find oil sands east of the Salinas River was North American Oil Consolidated's Rosenberg No. 1, in Sec. 34, T. 22 S., R. 10 E. The discovery well for the San Ardo field was The Texas Company's Lombardi No. 1, completed in November, 1947. The discovery well for the Campbell pool was Jergins-North American's Orradre No. 1, Sec. 12, T. 23 S., R. 10 E. This well was completed as a 5,000 MCF gas well in May, 1948.

4. Salinas Valley Microfauna, R. Stanley Beck, consultant, Bakersfield, Calif.

Observations concerning some of the microfauna encountered in wells in the San Ardo oil field and adjacent wildcats in the Salinas Valley.

5. West Area, Tejon Ranch Oil Field, L. C. Forrest, General Petroleum Corporation, Bakersfield, Calif.

This field was discovered by British-American Oil Producing Company and The Capital Company upon completion of Tejon No. 41-5, in Sec. 5, T. 10 N., R. 19 W., on December 14, 1945. Initial production on pump was 86 B/D of 15.5° gravity oil cutting 6% mud. At present there are 49 producing wells with a daily average production of approximately 2,800 B/D of 16° gravity oil. Average completion depth is 2,600 to 2,700 feet. Maximum thickness of the producing sand, Chanac-Santa Margarita Transition (?), is 80 feet.

6. Geology of Hungry Valley Area, South of Gorman, John Crowell, University of California at Los Angeles, West Los Angeles, Calif.

During late Tertiary time a thick section of coarse and fine continental clastics accumulated in the northwestern part of the Ridge basin. Deposition was concurrent with movement on the San Gabriel fault which bounded Ridge basin on the southwest. Movement on this fault ceased in early Pleistocene (?) time and the younger sediments overlapped southwestward across the fault and onto a pediment cut into the basement. Later in the Pleistocene the low-angle Frazier Mountain thrust moved relatively southeastward across the veneer of sediments on the pediment and in part onto the thick Ridge basin deposits. Subsequently the thrust, veneer of sediments, and pediment were folded and faulted along an east-northeast and west-southwest trend.

7. Russell Ranch Oil Field, Cuyama Valley, Mason L. Hill, Richfield Oil Corporation, Bakersfield, Calif.

The Cuyama Valley, lying in the Coast Ranges midway between the San Joaquin and Santa Maria districts, was established as a commercial oil producing province by the completion of Richfield Oil Corporation's Russell No. 28-5, on June 13, 1948. This new field is known as the Russell Ranch oil field. It is situated in the western portion of the valley and is producing from Lower Miocene sands on fault closures. Previously less than a dozen holes and one small producer from upper Miocene sand (Norris Oil Company's Cuyama No. 2) had been drilled in the valley.

Geologically the Cuyama Valley, between the Caliente and San Rafael uplifts, comprises granitic basement and Cretaceous to Pliocene strata folded and faulted in east-southeast trends. Eocene strata are present only in the eastern part of the valley, the Oligocene (?) is a red bed facies, 5,000 feet of lower Miocene sands pinch out southwestward, marine Miocene shales and sands grade eastward into red beds and the Pliocene strata are entirely non-marine.

Initial production of the discovery well, Richfield Oil Corporation's Russell No. 28-5, was 508 barrels per day, flowing, 38° gravity oil, from the interval 2,970-3,360 feet. This interval is lower Miocene and has been designated the Dibblee zone. Five days later another pool was established 2½ miles northwest by completion of Richfield Oil Corporation's Anderson No. 37-30, flowing 3,041 barrels per day, 33.5° gravity oil, from the interval 2,800-3,019 feet, also lower Miocene. The former, named the Russell area, had on October 1, 1948, eight completed wells with initial rates to 2,500 barrels per day, and maximum sand interval of 350 feet. The latter, designated Whiterock area, had nine completed wells with initial rates to 4,000 barrels per day, and maximum sand interval of 480 feet. Also, on October 1, 1948, the Russell Ranch field has eight active development wells, while eight wildcats were drilling at locations as far as 9 miles from production.

8. Airborne Magnetometer Profile across Cuyama Valley, Wayne Hoylman, Fairchild Aerial Surveys, Incorporated, Los Angeles, Calif.

Several northeast-southwest airborne magnetometer profiles across the structural trends in the Cuyama Valley, Caliente Range and Carrizo Plains area, including the Russell Ranch oil field, will be shown in comparison with a geological cross section of the same areas with interpretative comments.

9. Oceanic Sand, J. H. McMasters, Honolulu Oil Corporation, Bakersfield, Calif.

The Oceanic sand was named from its discovery as an oil producing zone in the Independent Exploration Company's well Oceanic No. 1, Sec. 22, T. 29 S., R. 21 E., Cymric field, in 1945. Its stratigraphic position is in the Refugian stage of the Oligocene series, and it is correlated in general with the "Y" zone of North Belridge field and the Wagonwheel sand outcropping north and southwest of Wagonwheel Mountain in the Devils Den region. The limits of its areal distribution are rather loosely controlled except on the west, but in general they define a narrow band extending from Devils Den at least as far south as McKittrick.

The economic importance of the Oceanic sand has been established in the Belgian anticline, Cymric, Bacon Hills, and North Belridge fields, and continued exploration should develop other pools.

10. West Mountain Oil Field, Leo H. Moir, Jr., Wilshire Oil Company, Incorporated, Los Angeles, Calif.

The West Mountain oil pool is a part of the South Mountain oil field and is the most westerly dome on the anticlinal Oak Ridge uplift in Ventura County, California. Normal faulting separates this fold into three blocks, each with different productive capacities. The oldest beds outcropping on the structure are of Oligocene (?) Sespe age. Drilling has penetrated this formation which is divisible into an upper and lower part on the basis of lithology. Saturation is confined to bottom conglomeratic portion of the "upper" division and the upper 1,500 feet of the "lower" division. A peculiarity of this "lower" division is the lenticular nature of the strata and their reaction to the waters normally used in the drilling muds. The Eocene beds have been penetrated, but the contact lacks sufficient lithological or foraminiferal character to determine the exact point of contact. Sands within this gradational zone show some saturation, but are as yet untested. At present, 27 wells drilled in this pool have proved at least 325 acres and have produced to date over 425,000 barrels of oil.

11. Major Elements of Utah Geology and Current Exploration Program, J. Stewart Williams, Utah State Agricultural College, Logan, Utah.

A general discussion of the stratigraphy and structure of the sedimentary areas of that part of the Colorado Plateau and eastern Basin and Range province located in this state.

The current exploration program has already resulted in two discoveries, one by Equity Oil Company on the north limb of the Uinta basin and the other by The California Company near Escalante in the Kaiparowitz basin in the southwest part of the state.

12. Possibilities of New Stratigraphic Trap Areas in Rocky Mountain Region, Henry Carter Rea, consultant, Casper, Wyoming.

The Rocky Mountain region offers every type of structural and stratigraphic trap favorable for the accumulation of oil. The presence of many well defined surface anticlines has given the impression that this region is strictly a structural province and the stratigraphic trap has been relegated to a place of minor consideration.

Because of the profitable development of the Cretaceous sand traps along the east side of the Powder River basin of Wyoming, this type of accumulation will be elaborated on to indicate that where similar geologic conditions exist in other of the Rocky Mountain basins the same type of production can be expected.

Fundamental in this concept of sand trap accumulation is that structural considerations as we know them, do not apply. To discuss the various theories on the origin, migration and accumulation of oil to account for this type of accumulation is to beg the question. The fact has to be recognized that the Cretaceous sands of the Rocky Mountain region are extremely lenticular and are capable of forming favorable traps for the accumulation of oil due to the lensing of the sand members themselves—on structure, on regional dip, and in synclines.

To date no method, other than the drill, has been devised to isolate an oil-bearing sand lens with any degree of certainty that one will be found. This "punch-board" type of exploration and development drilling is frowned upon as being unscientific, but it has proved very profitable to many operators in the Powder River basin of Wyoming. From the economic standpoint it has several

advantages in that very little preliminary geological work is required; because geophysics are of no aid in this problem they do not have to be considered; drilling depths can be chosen to suit the operator's equipment and finances; and finally, considerable latitude is offered in choosing a well site. Since there is no relationship between depth to the sand (if present) and production, the cost of exploring a sand lens area with wells 2,000 feet in depth (or less) would be commensurate to a core drill program of similar depth.

To support the contention that accumulation of the type discussed is more dependent on reservoir media than on structural considerations the following producing areas are cited.

1. Shannon pool off north plunge of Salt Creek, and Bothwell syncline west of Salt Creek field
2. Dakota production in Big Muddy field
3. Dakota production in East Lance Creek field
4. Dakota production in North Ant Hills area
5. Newcastle sand, Dakota and Lakota production in Mule Creek field
6. Dakota production in Bridge Creek area
7. Muddy or Newcastle sand production in Mush Creek-Newcastle-Osage fields
8. Dakota production in Lodgepole area
9. Frontier production in Upton-Thornton area
10. Newcastle sand production in Moorecroft area

All of the examples are in the Powder River basin of Wyoming.

In conclusion it should be mentioned that there are many other areas in the Rocky Mountain region where production of the type discussed can be obtained. It can be further stated that in any one of the Rocky Mountain basins where Cretaceous rocks are present the possibilities for sand trap accumulation exist.

13. Recent Developments in Canada, L. M. Clark, Barnsdall Oil Company, Calgary, Canada.

Recent oil developments in Canada have been largely restricted to Alberta. Some exploratory work, including drilling, has been carried on in northeastern British Columbia, Saskatchewan, Manitoba, Ontario, and the Maritime provinces. Geophysical exploration in Alberta has reached an all time high with forty seismographs, nine gravity meters, one magnetometer and a number of core drills and stratigraphic drills operating. This work has been largely concentrated in the Central Plains, although the Southern Plains and foothills are receiving considerable attention. Recent important discoveries, in addition to the Leduc oil field which produces oil from two dolomite zones in the Upper Devonian as well as from a Lower Cretaceous sand, include the Gulf Pincher Creek Mississippian limestone gas and condensate discovery in the southern foothills, and Imperial's Redwater No. 1 well which appears to have found another Devonian oil field thirty miles northeast of Edmonton. Other recent finds include a small Lower Cretaceous sand discovery at Bantry jointly by California Standard and Imperial, several pool extensions in the Lloydminster oil field, a gas discovery in the Cretaceous Peace River sand of the Peace River district of northeastern British Columbia and northwestern Alberta by Pacific Petroleum Limited, and a small heavy oil discovery by Bata Petroleum near the Alberta-Saskatchewan boundary eighty miles south of Lloydminster in a Lower Cretaceous sand.

One hundred and thirty wells were drilled in Alberta during the first six months of 1948. Using the A.A.P.G. classification, there were 110 completions, 74 of which were field development and 36 exploratory wells. Five field development wells were dry holes. Considering the exploratory wells, 5 outpost wells were successful and 5 were dry holes. Among the new field wildcats, Imperial's Woodbend No. 1, north of Leduc, discovered what is probably a new pool. Of the approximately 165,000,000 acres comprising the Province of Alberta, approximately 41,000,000 acres are currently held under lease or reservation.

14. History of Continental Shelf of Gulf of Mexico, Paul Weaver, national president, A.A.P.G., Houston, Texas.

Some authors consider the shore line as a hinge line with the land surface uplifted and the shelf downwarped. The author shows that this is by no means the general case and especially describes the geology of the shelf in the Gulf of Mexico.

15. Jasmine Oil Field, Robert W. Casey, Pacific Oil and Gas Development Corporation, San Francisco, Calif., and Fred Sperber, consultant, Bakersfield, Calif.

This field was discovered by Pacific Oil and Gas Development Corporation, July 25, 1946, upon completion of Canteberry No. 72-5 pumping 84 B/D of 13.5° gravity oil from the interval 2,763-2,794 feet in the lower Vedder zone. At present there are seven producing wells in the field.

16. Gujarral Hills Discovery, J. Q. Anderson, Barnsdall Oil Company, Bakersfield, Calif.

Commercial production was obtained by the Barnsdall Oil Company from Gujarral Hills on September 19, 1948. The producing sand is apparently a large lentil in the so-called "Leda zone" in the upper part of the Kreyenhagen shale formation. Productive limits of the "Leda sand" as well as the oil possibilities of the Eocene-McAdams sand will be determined by future drilling.

17. Miocene-Pliocene Boundary in Los Angeles Basin from Viewpoint of Microstratigrapher, Stanley G. Wissler and F. D. Crawford, Union Oil Company, Los Angeles, Calif.

Wells drilled in the central portion of the Los Angeles basin normally penetrate an unbroken depositional sequence from the upper Pliocene into the Mohnian stage of the upper Miocene. For some twenty years oil company microstratigraphers have placed the Miocene-Pliocene boundary at the base of the continuous occurrence of such typical Repetto foraminifera as *Karreriella milleri* Natland, *Hopkinsina hispida* (Schwager), *Bulimina rostrata* Brady, etc., and at the approximate upward limit of *Rotalia garveyensis* Natland, *Uvigerina hootsi* Rankin, and a related costate *Uvigerina*. Furthermore, there is a pronounced change in the preservation of the forams as the tests of the Miocene forms are generally so badly crushed by compaction that only a small portion of the fauna can be extracted by washing. Many foraminiferal species are common to both the lower Pliocene Repetto and the upper Miocene Delmontian, and in the Delmontian there are rare intermittent occurrences of some of the more typical lower Pliocene forms.

There is no marked lithologic break at the boundary, but the Miocene shales in general tend to be more laminated, and short intervals of hard, platy, "poker chip" type shale are commonly encountered a short distance below the contact. Platy shales become more abundant with depth, and the color gradually changes from the dominant hair brown of the lower Repetto to the dark chaetura drab of the upper Miocene. In the laminated Miocene shales, the foraminifera normally are concentrated in thin layers, while in the more massive Pliocene shales they are rather evenly distributed throughout the matrix.

MID-YEAR REPORT OF COMMITTEE ON BOY SCOUT LITERATURE

FRANK GOVIN¹

Duncan, Oklahoma

The main function of the committee, as the name implies, is that of getting some geology into the Boy Scout literature. R. C. Spivey, of our committee, heads a committee of the West Texas Geological Society which is working up the basic suggested Merit Badge pamphlet on Geology. This committee expects to have a rough draft prepared by mid-January. Various members of the committee will then be assigned subjects in which they are most proficient to be written in final form. Don Carroll will write the introduction and edit the pamphlet. Before this report appears in print it is hoped that another subcommittee will have accepted the responsibility of drafting a suggested Merit Badge pamphlet on Physiography.

The committee backed a program in Geology Exploration at the Philmont Senior Scout Ranch at Cimarron, New Mexico, the past summer. This 130,000-acre Ranch was given to the Boy Scouts of America by Waite Phillips. To finance the Ranch program he also gave the Scouts the Philtower Building in Tulsa. Senior Scouts, boys 15 through 18 years of age have the privilege of being on the Ranch for 5-14 days during the summer, taking any of a number of extremely interesting programs. In the spring and fall, Scout executives come there for field training. James P. Fitch is manager of the Ranch and of the Philtower Building. He was for years Chief Scout Executive of Region 9 with headquarters at Dallas. Region 9 includes the states of New Mexico, Oklahoma, and Texas. Mr. Fitch has long dreamed of what he calls "The University of the Out-of-Doors" for Scouts in which geology plays a very vital part. George A. Bullock is director of the program on the Ranch. We have never seen two men more enthusiastic for our geology program.

More than 2,000 Senior Scouts from councils located throughout the United States

¹ Chairman. Manuscript received, October 30, 1948.

were at Philmont the past summer. Each group of ten boys is accompanied by an adult leader. There were three groups of young men who took the 2-week course in Geology Exploration, the first time such a course has been given in the history of Scouting. Kenneth G. Brill, associate professor of geology at Saint Louis University, led a group from the Glendale, California, council. J. B. Leiser, geologist for the Shell Oil Company, Inc., at Tulsa, led a group from the Middletown, New York, council. A third group of 16 Senior Scouts from the Highland Park, Illinois council was instructed by Professor Ray Six of Oklahoma A. & M. A geology major from Oklahoma University, who had had several years experience as an assistant on the staff at Philmont, was the geological liaison man. Each group wrote a joint report at the close of the course. Guest cabins and excellent rations were furnished each geologist and his family by the Philmont authorities. The other expenses were paid by the committee. These expenses amounted to approximately \$600 of which \$150 was donated by the West Texas Geological Society and the balance given anonymously.

Your chairman was at Philmont just prior to the arrival of the first geology group to check the program. He visited the Ranch again the first week in August after the second group had finished, he was present the last week in August when the third and last group graduated so that he could talk to the young men and their adult leader who accompanied them from Illinois. It is astounding how much geology these high-school lads absorb in so short a time.

The geology liaison man also conducted 25 groups of 20-30 young men on a 2-day overnight hike to the copper mines on the Ranch and explained the simple geology *en route*. There are six base camps on the Ranch where groups stay over night. At two of these the camp directors were also geology students, one at Texas University, the other at the Colorado School of Mines. These young men had arranged a museum of rocks and fossils at their camps and gave lectures on the general geology to every group. More than 2,000 young men got some exposure to geology there during the summer.

We are already planning the 1949 season, which will be during July and August. That will give time for four groups of 2 weeks each. But the Ranch has facilities for more than one geology group being present at the same time. We need instructors for these groups. At least one geologist who was there the past summer desires to come again in 1949. The facilities for the geologist and his family are as good as one will find at any dude ranch in the Rockies. There is no more diversified geology anywhere. Good aerial photos cover the entire Ranch and its environs. The most modern practices in conservation are practiced on the Ranch so that it is easy to delineate the borders of the Ranch from the air, as did your chairman, by the better timber, grass, and crops, than on the land surrounding it. The fishing on the fine mountain streams on the Ranch is limited to the Scouts and to the staff. All game found in the Rockies can be seen on the Ranch as it is a game refuge. If any experienced geologist would like to have a paid vacation for himself and family our committee will be glad to consider his application.

National Headquarters of the Boy Scouts of America has asked us to describe the geology and physiography of some of their council camps. We should like to get those affiliated societies close to some council camp to do this. In many parts of the country there are colleges and universities having departments of geology which are located close to some council camp. There should be some cooperative method where graduate students and even undergraduates under faculty supervision could work up this information if some Boy Scout council camp were close enough. The Ardmore Geological Society has already named a committee to geologize the council camp close to them. Such a program will instill an interest in geology by the Scout leaders in the councils so that they can give the boys a program in geology to work on, and will also give us an average of conditions throughout the country so as to make our final Merit Badge pamphlet something that any boy can pass no matter where he resides. Our Philmont program is providing good data for the pamphlet by trying ideas in the field.

The committee is indebted to Dr. Brill, Mr. Leiser and Prof. Six for the fine way in which they gave their time and worked with the young men at Philmont the past summer. We are indebted to the whole-hearted cooperation of Mr. Fitch, Mr. Bullock, Mr. Church and the entire staff at Philmont. These men did everything to insure the success of the program.

INTERNATIONAL GEOLOGICAL CONGRESS, 18TH SESSION,
LONDON, AUGUST, 1948

J. HARLAN JOHNSON¹
Golden, Colorado

The sessions of the International Geological Congress included four types of activity: (1) technical sessions; (2) field trips; (3) meetings of the Council; (4) committee activities; and (5) social functions.

1. *Technical sessions.*—The technical sessions were held between August 25 and September 1. They were divided among sections as here listed.

Section	Subject
A	Problems of Geochemistry
B	Metasomatic Processes in Metamorphism
C	Rhythm in Sedimentation
D	The Geological Results of Applied Geophysics
E	The Geology of Petroleum
F	The Geology, Paragenesis and Reserves of the Ores of Lead and Zinc
G	The Geology of Sea and Ocean Floors
H	The Pliocene-Pleistocene Boundary
J	Faunal and Floral Facies and Zonal Correlation
K	The Correlation of Continental Vertebrate-Bearing Rocks
L	Earth Movements and Organic Evolution
	Symposium—Lead and Zinc
	Assn. Service Geologique Africains
	International Paleontological Union
	Mineralogy of Clays
	Committee on Pliocene-Pleistocene Boundary

The meetings were held in several places. The general sessions met at Albert Hall, while the individual sections held meetings in several rooms in the Imperial Institute and in the Royal School of Mines. During the period of August 26–30, five or six session meetings were usually occurring simultaneously. The sessions were very well attended; in fact, some rooms were hardly large enough to take care of those who wished to attend. The program printed before the beginning of the Congress gave abstracts of 389 papers, and additional papers were presented during the sessions. Most of these papers will be published in the *Proceedings* of the Congress.

The Congress headquarters was in the Geological Survey and Museum building, with the offices on the basement floor and a large and comfortable lounge on the fourth floor. Membership was approximately 1,785 from 80 countries. The official languages were English, French, Italian, German, and Spanish.

2. *Field trips.*—The field trips were divided into three groups: the "A" trips, which were taken before the Congress; the "B" trips during the Congress; and the "C" trips after the Congress. There were nineteen trips in the first group, covering practically all of Great Britain. Most of these were 10-day trips, although some required 14 days. They were very well attended and, in spite of bad weather, were found very interesting. The "B" trips consisted of half-day and full-day excursions to localities of geological interest within a radius of 100 miles of London. Ninety were given during the period between August 21 and September 2. Most of the short trips were taken by bus, though a few used the

¹ Colorado School of Mines. Professor Johnson represented the American Association of Petroleum Geologists delegation on the Council of the Eighteenth International Geological Congress.

railroad. The "C" trips resembled the "A" trips; in fact, some of them were identical. In length they ranged from 1 to 2 weeks and covered all parts of the British Isles. His Majesty's Government very generously presented all members of the Congress from abroad with a set of splendid regional guide books covering the British Isles.

3. *Business in Council*.—The Council was the business organization of the Congress and was composed of the delegates from the various countries and scientific organizations. A number of important items were brought up and considered. They are listed here with brief comments on the action taken.

(a) Introduction by the Delegation of the U.S.S.R. of a proposal that the Russian language be made an official language of the Congress. This matter was seriously considered at several of the Council meetings. It was pointed out that Russia was represented by only nine members of a total of more than 1,700 and that there were technical difficulties in preparing Russian texts of the proceedings. However, when the matter was brought to a vote, the official American Delegation favored the proposition and undoubtedly strongly influenced its passage. The Russian Delegation promised to take care of preparing the Russian texts.

(b) A proposal to appoint a Temporary Commission to report on problems connected with the Pliocene-Pleistocene boundary. This matter excited much interest and was actively supported.

(c) A proposal to appoint a Commission for the preparation of a World Physiographic Province Map. This was approved.

(d) Presentation by W. Wahl of a proposal for international cooperation in the accurate chemical analysis of meteorites. This was referred to the Executive Council for consideration and action.

(e) Presentation by J. Schurman, on behalf of the Netherlands Geological and Mining Society, of a recommendation concerning the definition of the Pleistocene-Holocene boundary. This matter aroused the interest of a number of members of the Congress. It was proposed that the subject be considered until the next meeting of the Congress when action might be taken.

(f) Presentation by J. Schurman, on behalf of the Netherlands Geological and Mining Society, of a recommendation that the Congress attempt to promote the revival of certain journals of abstracts. The suggestion was carefully considered and discussed. However, the opinion of the majority seemed to be that the present publications adequately take care of the matter and that additional journals of abstracts are unnecessary.

(g) Presentation by G. F. Herbert Smith, on behalf of the Society for the Promotion of Nature Reserves, of a recommendation concerning national geological reserves. Discussion of this proposal centered largely around the need of protecting certain type stratigraphic localities so they may be available for future generations.

(h) Discussion of the question of forming an International Union of Geology. The need of forming an International Union of Geology was carefully considered. It had been turned down in earlier sessions of the International Geological Congress. The memorandum given Council members stated:

UNESCO and the International Council of Scientific Unions have recently made a mutual agreement whereby UNESCO turns to the International Council and to its existing affiliated Unions for scientific advice; and whereby UNESCO may grant funds to the International Council or affiliated Unions for the prosecution of scientific projects of international importance.

UNESCO has expressed the hope that an International Union of Geology may be formed and affiliated with the International Council of Scientific Unions, so that there may be a permanent international geological executive to which UNESCO may turn for advice and with which it may cooperate.

This was considered by many to place the matter in a different light and to show a real need for a Union. In presenting the matter to the Congress, the Secretary suggested that there were three possibilities, one of which should be acted on by the Congress. These were: (1) that the Congress agree to union now; (2) that action on the entire matter be

postponed until the next meeting of the Congress (in 1952); or (3) that the Congress approve the appointment of a temporary committee to act in association with UNESCO until the next meeting of the Congress.

The third suggestion was the one considered by the Council, and it was finally passed in spite of very vigorous Russian opposition.

(i) Time and place of meeting of next session of International Congress. Two countries, India and Algeria, officially invited the next session of the Congress to meet in their capital cities. Both invitations were warmly received and carefully considered. Finally it was decided to meet in Algeria, as it appeared that a much larger number of geologists would be able to get to Algeria than to India. Time—1952, the technical sessions to be held late in August and the excursions during September.

4. *Committee activities.*—In all large organizations the great bulk of the work is done by committees. This was the case at the Congress. Besides a large number of standing committees, there were many special committees. The somewhat routine reports of many of these committees were read and passed on at the final meeting of the Council. Several working on special problems will have detailed reports included in the published *Proceedings*.

5. *Social functions.*—In the course of the Congress there were a number of social functions. Because of stringent clothing rationing in Britain, these were informal as to dress.

There was an informal get-together the evening of August 24 in the Geological Museum. It was attended by nearly all the delegates, members, and their relatives and friends, and helped greatly in getting members acquainted and in starting the meetings on a less formal basis.

His Majesty's Government gave a formal reception to delegates, members, and their relatives on the evening of August 25 at Lancaster House, St. James. It was a smoothly run formal affair but was so crowded that it was almost impossible to see who was there. Fortunately, as it did not rain that evening, most of the party was held in the garden.

The University of London had a reception on the evening of August 30, and the Geological Society of London and the Petroleum Institute held receptions on the evening of August 31.

In addition, the British Museum held open house, and several other museums had special exhibits for the benefit of Congress members.

The Congress and all its activities were beautifully planned and executed. The various committees deserve the thanks of the entire geological profession for their careful planning, hard work, and unfailing courtesy.

D. J. DOEGLAS TO ACT AS INTERNATIONAL SECRETARY FOR
SEDIMENTARY PETROLOGISTS²

About 40 people interested in sedimentary petrology attended a special meeting in London on Wednesday, September 1, the last day of the 18th International Geological Congress; Percival Allen of Cambridge University presided. The purpose of the meeting was to review briefly recent work in sedimentology, particularly in Europe, and to discuss means of facilitating an exchange of ideas. D. J. Doeglas discussed the trends in sedimentology in the Netherlands, André Vatan outlined recent work in France, and Percival Allen summarized British work. There was considerable discussion of future trends and the relative value of various types of research.

No organization specifically devoted to sedimentology exists in Europe at present, though a Congress on Sedimentary Petrology has been held in Belgium since the war and it is hoped that such congresses will continue. Jacques J. Bourcart announced that a small one is planned for May, 1949, in France; the meeting will probably be in Paris with excursions.

² Note by R. Dana Russell.

sions planned to the Cote de Bretagne and La Rochelle. The group decided not to attempt the organization of a special society or other formal organization at this time, but to appoint informally an international secretary to act as a clearing house for information. It was also decided to request the International Geological Congress to establish a Section on Sedimentology at the next meeting of the Congress.

D. J. Doeglas, Afdeling Geologie en Mineralogie, Landbouwhoogeschool, Wageningen, Netherlands, was unanimously elected International Secretary. Percival Allen, Sedgwick Museum, Cambridge University, England, was asked to prepare a summary of the discussions for distribution to those attending. It is hoped to print this summary in the next issue of the *Journal of Sedimentary Petrology*.

SCIENTISTS AND RESERVE OFFICERS

The Department of the Army has established a program of particular interest to petroleum geologists and other scientists who hold Reserve commissions in the Army, and who are professionally engaged in teaching or research and development.

The objectives of the program are to:

- (1) maintain the useful affiliation of petroleum geologists and other scientists with the Organized Reserve Corps,
- (2) provide peacetime Reserve assignments for these officers, enabling optimum utilization of their education, experience and skills,
- (3) furnish mobilization assignments which will fully utilize their talents, and
- (4) adequately prepare these officers for mobilization.

The Technical Services of the Department of the Army submit to these Research and Development Reserve Groups research problems and projects which pose an intellectual challenge to members of the group. Thus, the program provides members of each group a type of training which is in keeping with their scientific and technical interests and competence, rather than a traditional kind of training session in which scientists have little or no interest.

The program is now being implemented only in those areas where there is a definite local interest. To date, eighteen Research and Development Reserve groups have been organized. Twelve additional groups are in process of organization. Others are in the initial stages of formation. Several of these groups have been formed in communities in which large universities, industrial research laboratories, or private research foundations are located. Typical localities are Chicago, Illinois; Wilmington, Delaware; Newark, New Jersey; Houston, Texas; Washington, D.C.; Manhattan and Lawrence, Kansas; Champaign-Urbana, Illinois; Pittsburgh, Pennsylvania; Denver, Colorado; and Detroit, Michigan.

Provision is made to submit research projects of interest in all categories of scientists—chemists, physicists, engineers, geologists, geographers, psychologists, mathematicians, and all of the biological scientists.

Reserve officers who are currently engaged in civilian research, college or university teaching, or industrial research or development, or who in the past have had specific research experience are eligible to make application for assignment to an Organized Reserve Research and Development Group. A group may be organized in any locality where there are twenty (20) or more qualified officer scientists who desire to participate in the program. A subgroup may be organized with ten (10) qualified members.

The program is under the general direction of the Research and Development Group, Logistics Division, General Staff, United States Army. The entire program is outlined in Department of the Army Circular Number 127, dated May 5, 1948.

Inquiry about organization of an Organized Reserve Research and Development Group or about assignment to a group already organized should be made of the Unit

Instructor, ORC, or of the Senior Army Instructor, ORC, in the locality in which the officer resides. In localities in which a group has already been organized, the Commanding Officer of the group will consider applications for assignment of additional officers.

DEPARTMENT OF THE ARMY

Washington 25, D. C., May 5, 1948

CIRCULAR 127

Effective until November 5, 1949, unless sooner rescinded or superseded

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V. **RESERVE OFFICERS.**—1. Purpose.—Preparation for modern warfare continues to make increasingly greater demands for more complex weapons and matériel; for increased applications of all fields of science, pure and applied; and for more highly trained scientific, medical, and engineering personnel to develop or design new weapons, to devise new uses for existent weapons and equipment, to safeguard the lives and health of the civilian populace as well as the uniformed forces, to operate the complicated technical machines of warfare, and to train others in their use. It is the purpose of this circular to provide a program for Reserve officers who are professionally engaged in research and development activities, in order to insure their optimum utilization in peace and war.

2. Objectives.—a. To establish a program for Reserve officers who are professionally engaged in research or development which will—

- (1) Maintain the useful affiliation of this type of personnel with the Organized Reserve Corps.
- (2) Provide peacetime assignments for these officers, enabling optimum utilization of their education, experience, and skills.
- (3) Furnish mobilization assignments which will fully utilize their talents.
- (4) Adequately prepare these officers for mobilization.

b. To establish adequate means for the selection of Reserve officers of this category to participate in this program.

3. Procurement.—Procurement of officers will be governed by the provisions of pertinent directives as published from time to time.

4. Organization.—a. In those military districts where there is a sufficient number of Reserve officers who are professionally engaged in research and development, the senior State instructor will recommend the formation of one or more Organized Reserve Research and Development Groups or Subgroups. This recommendation will include the names of those officers who are technically qualified and desirous of participating in this program, and will furnish sufficient pertinent information concerning each officer named to confirm his selection. This information will include—

- (1) Educational attainment.
- (2) Present occupation.
- (3) Past civilian and military professional experience.
- (4) Bibliography of publications.
- (5) Scientific and professional society memberships.

b. In addition, one officer will be recommended as commanding officer of the proposed group or subgroup.

c. The recommendations in *a* and *b* above will be forwarded through channels to The Adjutant General, Attention: AGPR-D, for final approval and authority for activation of the Organized Reserve Research and Development Group or Subgroup. Upon receipt of final approval and authority for activation, the army commander will organize the appropriate Organized Reserve Research and Development Group or Subgroup.

d. A minimum of 20 officers is required for the formation of an Organized Reserve Research and Development Group.

e. In areas where there is an insufficient number of professional research and development personnel to establish an Organized Reserve Research and Development Group, qualified Reserve officers may be organized into Organized Reserve Research and Development Subgroups, attached for administrative purposes to an appropriate training group. The administrative procedure for the formation of these subgroups will be as outlined in *a*, *b*, and *c* above. Such subgroups will be composed of not less than 10 officers, except that in special cases the senior State instructor may recommend the formation of a subgroup of less than 10 officers.

5. Selection.—a. Final selection of qualified Reserve officers for participation in this program will be made by the Department of the Army.

b. A roster of officers assigned to Organized Reserve Research and Development Groups and Subgroups will be compiled by The Adjutant General annually as of 31 October, and will be distributed to all General Staff divisions; Office, Chief, Army Field Forces; commanding generals of area commands, and heads of technical services.

c. Reserve officers desiring to participate in this program may make application to the commanding officer of an appropriate Organized Reserve Research and Development Group; or if there is no

appropriate group yet established, to the senior State instructor or unit instructor. Applications will include the information required by paragraph 4a and b, and will be forwarded with appropriate recommendations through channels to The Adjutant General, Attention: AGPR-D.

6. Qualifications.—*a.* Reserve officers eligible for participation in this program must have the following professional qualifications:

- (1) Possess at least a Bachelor's Degree, from a college or university accredited by one or more of the recognized national or regional educational accrediting associations.
- (2) Be engaged in a professional capacity in research and/or development work in a field normally associated with one of the physical, engineering, medical, or biological sciences, including pertinent fields of psychology.

b. Professional employment in a field or activities more properly associated with routine or maintenance functions will not necessarily be considered as professionally qualifying an officer to participate in this program.

c. These requirements may be waived by the Department of the Army if the applicant's professional background and experience so warrant.

7. Security clearance.—*a.* The Research and Development Group, Logistics Division, General Staff, United States Army, and Office, Chief, Army Field Forces, may authorize an Organized Reserve Research and Development Group or Subgroup to receive such classified material, to include SECRET as may be necessary for the accomplishment of any projects assigned to the group by the heads of technical services in coordination with the Research and Development Group, Logistics Division, General Staff, United States Army.

b. Unless otherwise specifically prescribed, the senior State instructor or the unit instructor will be responsible that this classified material is properly safeguarded as prescribed by AR 380-5 and other pertinent directives.

c. Security clearance of Reserve officers of such groups or subgroups, prior to receiving SECRET material, will be the responsibility of the senior State instructor or the unit instructor. In accomplishing such security clearances, the responsible officer may request a check or investigation, as deemed necessary, from the appropriate army commander.

d. In making such security clearances, the procedure set forth in TM 30-218 will be followed.

8. Assignment.—*a. Peacetime.*—Reserve officers participating in this program will be given inactive duty assignments by the Department of the Army to Organized Reserve Research and Development Groups or Subgroups as prescribed in paragraph 4.

b. Mobilization.—When Reserve officers participating in this program are given mobilization assignments, such assignments will be to appropriate research and development installations or offices. These assignments will be made by the Department of the Army. Each assignment will be subject to review at any time by the using agency to determine that the officer concerned is still the best qualified officer available.

9. Training.—*a. General.*—Training will continue to be the responsibility of the Chief, Army Field Forces, within the policies established by the Department of the Army. The Research and Development Group, Logistics Division, General Staff, United States Army, and the heads of technical services will furnish technical assistance in the formulation of the program and the subject matter therein.

b. Inactive duty training.

(1) Orientation on the organization of research and development activities of the Department of the Army, of the Army Field Forces, and of the various technical services, including those boards and panels whose functions fall within the purview of research and development.

(2) Pertinent parts of courses from established schools and colleges of the armed forces.

(3) Review and editing of technical manuals and publications.

(4) Work on certain research and development matériel and non-matériel problems as assigned by the head of the appropriate technical service in coordination with Research and Development Group, Logistics Division, General Staff, United States Army.

(5) Review or formulation of plans to assist research and development organizations, boards, or panels in accomplishment of their mission.

(6) Review or formulation of planning methods or the evaluation of proposed tactics, techniques, and organization.

(7) Assistance to service schools in revising or broadening their training programs.

(8) In view of the technical qualifications of the Reserve officers participating in this program, they will be encouraged to formulate their own training programs encompassing research and development problems or projects of interest to the Department of the Army.

c. Individual training.—Reserve officers whose professional standing and reputation are outstanding in their field may be utilized in an inactive duty status on a consultant basis by all agencies of the Department of the Army for technological assistance in the formulation of research and development plans and programs, the review of technological subjects, and the solution of technological problems. In such cases, credit will be given for a commensurate number of inactive duty training hours in accordance with section III, Circular 71, Department of the Army, 1947.

d. Active duty training.—Subject to the availability of funds, Reserve officers assigned to Or-

ganized Reserve Research and Development Groups or Subgroups, may be assigned to research and development agencies, schools, and boards of the Department of the Army, the Army Field Forces, area commands, or the various technical services for active duty training upon request of the officer and approval of the establishment concerned; or upon request of the establishment and consent of the officer concerned.

10. Promotion.—Promotion of Reserve officers assigned to Organized Reserve Research and Development Groups will be governed by the provisions of pertinent directives as published from time to time.

11. Publicity.—Special effort will be made by all echelons to disseminate information contained in this circular through appropriate public relation facilities so that all details will be available to service, veteran, Reserve officer, professional society, college, and university publications.

VI. SCHOOL TRAINING.—1. In determining eligibility of Department of the Army enlisted personnel for school training under the provisions of section II, Circular 78, Department of the Army 1947, and Memorandum 615-515-1, as changed, the following policy will apply:

a. Assigned (pipeline) replacement stream enlisted personnel must have a minimum of 15 months to serve from the date of completion of the course in which they are to be enrolled.

b. In the event that sufficient enlisted personnel qualified under a above are not available to meet minimum essential requirements for school-trained specialists, the Department of the Army may order to Army service schools, assigned (pipeline) replacement stream enlisted personnel who will have less than 15 months', but more than 10 months', service remaining upon completion of the course in which they are to be enrolled. In order to effect maximum utilization of this category of personnel, every effort will be made to enroll them in short courses.

c. Enlisted personnel assigned to zone of interior units or installations must have a minimum of 6 months' service remaining upon completion of course in which they are to be enrolled, before being ordered to school on detached service.

2. Personnel who are otherwise qualified to receive school training, but can not meet the above requirements, may—

a. If enlisted in the Regular Army, and if extension of their enlistment to 3, 4, 5, or 6 years would qualify them under the provisions of paragraph 1, extend their enlistment under the provisions of Circular 66, AF Letter 35-114, Departments of the Army and the Air Force, 1948; or

b. Be discharged and reenlisted under the provisions of AR 615-365, as changed, and Circular 66, AF Letter 35-114, Departments of the Army and the Air Force, 1948.

3. Section V, Circular 355, War Department, 1946, pertaining to the foregoing subject, is rescinded.

VII. ORGANIZED RESERVE CORPS.—1. In view of the extreme difficulty in finding qualified company grade officers to fill table of organization and equipment vacancies in the Organized Reserve Corps, authority is granted to fill officer vacancies by assignment thereto of qualified individuals who are one grade higher than that specified by applicable tables of organization and equipment, subject to the following provisions:

a. There must be no officer available in the proper grade or one grade junior to that specified for the vacancy in question.

b. Officers so assigned shall be in grades up to and including the grade of captain only.

c. An officer so assigned shall be replaced immediately upon the availability of a qualified officer in the proper grade.

d. Officers so assigned shall be within the age limitations for the grade of the T/O & E vacancy to be occupied, as established by paragraph 306, Circular 356, War Department, 1946, as amended by Circular 70, Department of the Army, 1947.

2. The above authorization is an interim measure and may be revoked at any time the availability of officer personnel renders such revocation desirable, and, unless sooner revoked, expires 1 January 1951.

BY ORDER OF THE SECRETARY OF THE ARMY:

OFFICIAL:

EDWARD F. WITSELL

Major General

The Adjutant General

OMAR N. BRADLEY

Chief of Staff, United States Army

ARMY RESERVE COMMISSIONS FOR GEOGRAPHERS, GEOLOGISTS, GEOPHYSICISTS, AND METEOROLOGISTS

Reserve commissions in the Army of the United States are now available to qualified geographers, geologists, geophysicists, and meteorologists who meet the requirements of age, education, experience, and physical condition. The commissions range from that of Second Lieutenant up to and including full Colonel, depending on the qualifications and

experience possessed by the applicant in his specified field. Applicants must be at least twenty-one (21) years of age for appointment in the Reserve Corps, and applications will be considered from individuals up to fifty-five (55) years. All must be citizens of the United States. No previous military experience is required.

A bachelor's degree in geography, geology, geological engineering, geophysics, meteorology, or any included engineering or physical science field, qualifies for appointment into the Officers' Reserve Corps. The foregoing minimum education without any experience qualifies for appointment in the grade of Second Lieutenant.

For appointment in the grade of First Lieutenant through Colonel, applicants, in addition to the degree specified, must have had additional qualifying education or progressive professional experience in any one or any combination of the following areas.

1. Geology
 - a. Economic geology
 - (1) Petroleum geology
 - (2) Mining geology
 - (3) Geological engineering
 - (4) Hydrology
 - b. Physical or dynamic geology
 - (1) Mineralogy
 - (2) Petrology
 - (3) Structural geology
 - (4) Surficial geology
 - (5) Field (or areal) geology
 - c. Historical geology
2. Geophysics
 - a. Geophysical prospecting
 - b. Geophysical research
 - (1) Geodesy
 - (2) Geomagnetism
 - (3) Oceanography
 - (4) Tectonophysics
3. Meteorology
 - a. Daily weather forecasting
 - b. Synoptic
 - c. Meteorological instruments and measurements
 - d. Physical and dynamic meteorology
 - e. Long range weather forecasting
 - f. Climatology

The above experience may be in any one or any combination of the following activities:

1. Forecasting or geophysical or meteorological station operation
2. Prospecting
3. Research
4. Management or administration
5. Consulting
6. Teaching
7. Design, construction, or technical sales of pertinent machines and instruments
8. Analysis, testing, and inspecting, including industrial process control
9. Technical writing or editing
10. Museum work

Determination of the grade in which an applicant is to be commissioned is the function of the examining board which interviews the applicant, subject to final approval of The Adjutant General. The grade will be based on the total number of years of qualifying college education and/or experience according to the following scale of minimum requirements for each grade.

Second Lieutenant	— 4 years	Major	— 16 years
First Lieutenant	— 7 years	Lieutenant Colonel	— 21 years
Captain	— 11 years	Colonel	— 26 years

The Reserve sections for which these appointments will be made are: Corps of Engineers Reserve; Military Intelligence Reserve; Ordnance Department Reserve; Quartermaster Corps Reserve; and Signal Corps Reserve.

Full details of the program for commissioning of civilian geographers, geologists, geophysicists, and meteorologists are provided in Department of the Army Circular No. 210, dated July 14, 1948. Application forms and Circular No. 210 may be obtained from local Reserve Unit Headquarters or from Organized Reserve Unit Instructors, or by writing to Army Headquarters at New York, Baltimore, Atlanta, Chicago, Houston, or San Francisco. Inquiries and requests for application forms and the circular may also be addressed to The Adjutant General, Department of the Army, Washington 25, D. C.

34TH ANNUAL MEETING, ST. LOUIS, MARCH 14-17, 1949¹

The 34th annual meeting of the Association will be held at the Jefferson Hotel, St. Louis, Missouri, March 14-17, 1949. Concurrent meetings will be held by the Society of Economic Paleontologists and Mineralogists and the Society of Exploration Geophysicists. Hotel room reservation request forms have been mailed to all members, and these forms should be used without delay.

Technical program.—President Weaver has appointed W. B. WILSON, Gulf Oil Corporation, Tulsa, Oklahoma, to be chairman of the technical program committee for the A.A.P.G. NORMAN S. HINCHEY, Washington University, St. Louis, Missouri, is vice-chairman in charge of technical service.

Members planning to submit papers should send, *in duplicate*, in double spaced type-written form, their name, company or professional connection, subject of paper, and a 200-word abstract, to chairman WILSON, by January 1, certainly not later than February 1. Papers will be selected for the program to conform with the planned subject matter acceptable for oral presentation and to conform with the time available. Papers not acceptable for oral delivery may be included in the printed program by title and abstract.

Tentatively, the A.A.P.G. program will include a half day of presidential addresses and awards; a half day of papers of common interest for the joint session; a half day of oil-field descriptions; a half day of papers on the theme of "Reefs"; a half day devoted to foreign papers; and a half day of important miscellaneous papers.

Papers for the S.E.P.M. program should be submitted to Maynard P. White, S.E.P.M. chairman, Gulf Oil Corporation, Box 30, Ardmore, Oklahoma.

A.A.P.G. TECHNICAL PROGRAM COMMITTEE

W. B. Wilson, chairman, Gulf Oil Corporation, Box 660, Tulsa, Oklahoma	
Norman Hinchey, vice-chairman, Washington University, St. Louis, Missouri	
Hollis D. Hedberg, New York	George Sawtelle, Houston
Harold W. Hoots, Los Angeles	J. B. Webb, Calgary
E. W. Krampert, Casper	T. E. Weirich, Bartlesville
E. Russell Lloyd, Midland	

Exhibits.—Space has been arranged on the mezzanine for the display of up-to-date methods and equipment representing the highest scientific and professional efficiency in the exploration for oil and gas.

On the 2d floor, limited space will be available to educational institutions, government bureaus, and affiliated societies for the display of *new or recent*, significant maps, correlation charts, aerial photographs, *et cetera*, which may be fastened to vertical panels. These displays will necessarily be restricted to vertical space in units approximately 6 feet high by 5 feet wide. Tables will not be used. Requests for space should reach the A.A.P.G., Box 979, Tulsa 1, Oklahoma, before February 1.

¹ Previous announcements about this meeting have appeared in the *Bulletin* of July, pp. 1376-77, and November, pp. 2166-67.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

CONSTITUTION¹

ARTICLE I. NAME

This Association shall be called "The American Association of Petroleum Geologists," incorporated under the laws of Colorado.

ARTICLE II. OBJECT

The object of this Association is to promote the science of geology, especially as it relates to petroleum and natural gas; to promote the technology of petroleum and natural gas and to encourage improvements in the methods of exploring for and exploiting these substances; to foster the spirit of scientific research amongst its members; to disseminate facts relating to the geology and technology of petroleum and natural gas.

ARTICLE III. MEMBERSHIP

Members

SECTION 1. Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions, whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.

Life Members

SECTION 2. The executive committee may grant life membership to members who have paid their dues and are otherwise qualified.

Associates

SECTION 3. Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has the equivalent of one year's experience in the application of

¹ The constitution and by-laws were adopted 1918, and amended 1921, 1922, 1923, 1925, 1927, 1928, 1929, 1930, 1932, 1933, 1935, 1936, 1939, 1940, 1942, 1943, 1944, 1945, and 1946.

his science to the study of petroleum geology, shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in investigations in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.

The executive committee may advance to active membership, without the formality of application for such change, those associates who have, subsequent to election, fulfilled the requirements for active membership.

Election to Membership

SECTION 4. Every candidate for admission as a member or associate shall submit a formal application on an application form authorized by the executive committee, signed by him, and endorsed by not less than three members who are in good standing, stating his training and experience and such other facts as the executive committee shall from time to time prescribe. Provided the executive committee, after due consideration, shall judge that the applicant's qualifications meet the requirements of the constitution, they shall cause to be published in the *Bulletin* the applicant's name and the names of his sponsors. If after at least thirty days have elapsed since such publication, no reason is presented why the applicant should not be admitted, he shall be deemed eligible to membership or to associate membership, as the case may be, and shall be notified of his election.

With the notice of election shall be included a copy of the constitution and by-laws of the Association.

SECTION 5. An applicant for membership, on being notified of his election in writing, shall pay full membership dues for the current year and on making such payment shall be entitled to receive the entire *Bulletin* for that year. Unless payment of dues is made within thirty (30) days by those living within the continental United States and within ninety (90) days by those living elsewhere, after notice of election has been mailed, the executive committee may rescind the election of the applicant. Upon payment of dues, each applicant for membership shall be furnished with a membership card for the current year, and until such written notice and card are received, he shall in no way be considered a member of the Association.

Honorary Members

SECTION 6. The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues.

SECTION 7. Each member and associate shall be guided by the highest standards of business ethics, personal honor, and professional conduct.

SECTION 8. Any member or associate who, after due investigation, is found guilty of violating any of the standards of conduct prescribed in Section 7 of this Article, may be admonished, suspended, allow to resign, or dropped from membership in accordance with the procedure provided by the by-laws.

ARTICLE IV. OFFICERS AND THEIR DUTIES

Officers

SECTION 1. The officers of the Association shall be a president, a vice-president, a secretary-treasurer, and an editor. These, together with the past-president, shall constitute the executive committee and managers of the Association.

SECTION 2. The officers shall be elected annually from the Association at large by means of secret mailed ballot in the following manner. The nominating committee shall nominate one or more candidates for each office, and its nominations shall be published in the September *Bulletin*. Additional nominations may be made by written petition of fifty, or more, members in good standing received at Association headquarters not later than November 15. The executive committee shall then prepare a printed ballot, listing the candidates for each office, and one ballot shall be mailed to each member as soon after November 15 as possible. Ballots returned to Association headquarters on or before January 31 shall be placed as received in a locked ballot box and promptly after January 31 the ballot committee shall open the ballot box and count the ballots. Ballots of delinquent members shall not be counted. A majority of all votes cast for an office is necessary for election. If there are three or more nominees for any office, a preferential form of ballot shall be used. In case of a tie vote, the executive committee shall cast one additional deciding vote. Each candidate, when voted for as a candidate for the particular office for which he is nominated, shall be thereby automatically voted for as a candidate for the executive committee for one year, except that candidates for the presidency shall be automatically voted for as candidates for the executive committee for two years.

SECTION 3. No one shall hold the office of president for two consecutive years and no one shall hold any other office for more than two consecutive years except the editor who shall not hold office for more than six consecutive years.

Duties of Officers

SECTION 4. The president shall be the presiding officer at all meetings of the Association, shall take cognizance of the acts of the Association and of its officers, shall appoint such committees as are required for the purposes of the Association, except the nominating committee, and shall delegate members to represent the Association. He may, at his option, serve on, and may be chairman of, any committee, except the nominating committee.

SECTION 5. The vice-president shall assume the office of president in case of a vacancy from any cause in that office and shall assume the duties of president in case of the absence or disability of the latter. If the past-president shall for any reason be unable to serve as a member of the executive committee, the president shall fill the vacancy by the appointment of the next available preceding past-president.

A vacancy or disability occurring in the office of vice-president, secretary-treasurer, or editor shall be filled by majority vote of the executive committee, either for the unexpired term or for the period of disability, as the committee may decide. In the case of a tie, the president shall cast the deciding vote.

SECTION 6. The secretary-treasurer shall assume the duties of president in case of the absence of both the president and vice-president. He shall have charge of the financial affairs of the Association and shall annually submit reports as secretary-treasurer covering the fiscal year. He shall receive all funds of the Association, and, under the direction of the executive committee, shall disburse all funds of the Association. He shall cause an audit to be prepared annually by a public accountant at the expense of the Association. He shall give a bond, and shall cause to be bonded all employees to whom authority may be delegated to handle Association funds. The amount of such bonds shall be set by the executive committee and the expense shall be borne by the Association. The funds of the Association shall be disbursed by check as authorized by the executive committee.

SECTION 7. The editor shall be in charge of editorial business, shall submit an annual report of such business, shall have authority to solicit papers and material for the *Bulletin* and for special publications, and, with the approval of the executive committee, may accept or reject material offered for publication. He may appoint associate, regional, and special editors.

SECTION 8. The officers shall assume the duties of their respective offices immediately after the annual meeting, which follows their election.

ARTICLE V. EXECUTIVE COMMITTEE—MEETINGS AND DUTIES

Executive Committee

SECTION 1. The executive committee shall consist of the president, past-president, vice-president, secretary-treasurer, and editor.

Meetings and Duties

SECTION 2. The executive committee shall meet immediately preceding the annual meeting and at the call of the president may hold meetings when and where thought advisable, to conduct the affairs of the Association. A joint meeting of the outgoing and incoming executive committees shall be held immediately after the close of the annual Association business meeting. Members of the executive committee may vote by proxy on matters which require a unanimous vote.

SECTION 3. The executive committee shall consider all nominations for membership and pass on the qualifications of the applicants; shall have control and management of the affairs and funds of the Association; shall determine the manner of publication and pass on the material presented for publication; shall designate the place of the annual meeting; shall appoint the nominating committee and its chairman; and shall be in charge of the annual election of officers and decide eligibility and other questions pertaining to the election. They are empowered to establish a business headquarters for the Association, and to employ such persons as are needed to conduct the business of the Association. They are empowered to accept, create, and maintain special funds for publication, research, and other purposes. They are empowered to make investments of both general and special funds of the Association. Trust funds may be created, giving to the trustees appointed for such purpose, such direction as to investments as seems desirable to the executive committee to accomplish any of its objects and purposes, but no such trust funds shall be created unless they are revocable upon ninety (90) days' notice.

ARTICLE VI. MEETINGS

The Association shall hold at least one stated meeting each year, which shall be the annual meeting. The meeting shall be held in March or April at a time and place designated by the executive committee. At this meeting the election of members shall be announced, the proceedings of the preceding meeting shall be read, Association business shall be transacted, scientific papers shall be read and discussed and officers for the ensuing year shall be announced.

ARTICLE VII. AMENDMENTS

Amendments to this constitution may be proposed by a resolution of the executive committee, by a constitutional committee appointed by the president, or in writing by any ten members of the Association. All such resolutions or proposals must be submitted at the annual meeting of the business committee of the Association as provided in the by-laws, and only the business committee shall make recommendations concerning proposed constitutional changes at the annual Association business meeting. If such recommendations by the business committee shall be favorably acted on at the annual Association business meeting, the secretary-treasurer shall arrange for a ballot of the membership by mail within thirty (30) days after said annual Association business meeting, and a majority vote of the ballots received within ninety (90) days of their mailing shall be sufficient to amend. The legality of all amendments must be determined by the executive committee prior to balloting.

BY-LAWS

ARTICLE I. DUES

SECTION 1. The fiscal year of the Association shall correspond with the calendar year.

SECTION 2. The annual dues of members of the Association shall be ten dollars (\$10.00).

The annual dues of associates for not to exceed three years after election shall be six dollars (\$6.00); for the second three-year period eight dollars (\$8.00); thereafter, the annual dues of such associates shall be ten dollars (\$10.00). The annual dues are payable in advance on the first day of each calendar year. A bill shall be mailed to each member and associate before December first of each year, stating the amount of the annual dues and the penalty and conditions for default in payment. Members or associates who shall fail to pay their annual dues by January first shall not receive copies of the January *Bulletin* or succeeding *Bulletins*, nor shall they be privileged to buy Association special publications at prices made to the membership, until such arrears are met.

During any period in which the United States is actually engaged in war and for a period of one year thereafter, the executive committee may at its discretion suspend, reduce, or waive annual dues to members or associate members serving in the armed forces of the United States, or any allied country, without otherwise affecting their membership, except that they shall not receive the *Bulletin* during a period for which no dues are paid.

SECTION 3. On the payment of two hundred dollars (\$200.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay annual dues. The funds derived from this source shall be placed in a permanent investment, the income from which shall be devoted to the same purposes as the regular dues.

ARTICLE II. RESIGNATION—SUSPENSION—EXPULSION

SECTION 1. Any member or associate may resign from the Association at any time. Such resignation shall be in writing and shall be accepted by the executive committee, subject to the payment of all outstanding dues and obligations of the resigning member or associate.

SECTION 2. Any member or associate who is more than a year delinquent (in arrears) in payment of dues shall be suspended from the Association. Any delinquent or suspended member or associate, at his own option, may request in writing that he be dropped from the Association and such a request shall be granted by the executive committee. Any member or associate more than two years in arrears shall be dropped from the Association. The time of payment of delinquent dues for either one year or two years may be extended by unanimous vote of the executive committee.

SECTION 3. Any member or associate who resigns or is dropped under the provisions of Sections 1 and 2 of this article ceases to have any rights in the Association and ceases to incur further indebtedness to the Association.

SECTION 4. Any person who has ceased to be a member or associate under Section 1 or Section 2 of this article may be reinstated by unanimous vote of the executive committee subject to the payment of any outstanding dues and obligations which were incurred, prior to the date when he ceased to be a member or associate of the Association.

In the case of any member or associate who has been dropped between the dates of January 1, 1931, and January 1, 1936, for non-payment of dues and who shall apply for reinstatement, the executive committee is authorized, at its discretion, to accept the resignation of such member or associate effective at any date during such period of delinquency, provided, the member shall pay all indebtedness to the Association incurred prior to the date of such resignation including a proper proportion of annual dues as shall be fixed by the executive committee. Such member or associate shall not be entitled to receive the *Bulletin* for any period subsequent to the date when his resignation became effective and prior to his reinstatement.

SECTION 5. Charges of misconduct in violation of Section 7 of Article III of the constitution shall first be submitted in writing to the president of the Association by a member in good standing, in confidence, with a full statement of the evidence on which the charges are based. If in his judgment they merit further consideration, he shall appoint a committee to consist of three past-presidents of the Association, which shall examine into the charges. If in the judgment of said committee, the facts warrant, it shall prepare and file with the executive committee formal charges against the accused member or associate. As soon as may be after the receipt of such charges the executive committee shall fix a date and place for hearing thereupon, and shall give to the accused person notice thereof in writing, mailed to him by registered mail at his last-known post-office address not less than thirty (30) days before said date, accompanied by a copy of the charges, and a copy of this article.

SECTION 6. On the day fixed for the hearing, the accused person may appear before the executive committee, either in person or by an accredited representative; hear any witnesses who may be called in support of the charges; and, at his option, cross-examine the same, and hear any documentary evidence, including a statement from himself, in writing. At his option, he may by letter waive personal hearing, and request the executive committee to adjudge the matter on the basis of a written statement of his defense, mailed to the committee before the date set for the hearing. After the conclusion of the hearing, or study of written defense submitted in lieu of a personal hearing, the executive committee shall consider and vote to approve or disapprove the charges. If the executive committee shall, by unanimous vote, declare the charges sustained, it may suspend the accused person from membership for a stated period, admonish him, allow him to resign, or expel him. Failure of the accused person to appear either in person or by an accredited representative shall not prevent the executive committee from proceeding with the trial.

SECTION 7. If the accused person shall not appear at the hearing nor waive his right thereto, and shall within three months after the date set for the hearing file with the executive committee an affidavit stating that he had not received notice of the charges against him in time to enable him to present his defense, the executive committee shall fix a date and place for a hearing not less than thirty days nor more than three months from the receipt of such affidavit, and shall immediately notify the accused person by registered mail of such date and place. Upon the rehearing, the proceedings shall be governed by the provisions of Section 6 of this article.

SECTION 8. Resignation of the accused person from membership in the Association, at any stage of the foregoing prescribed proceedings, shall automatically terminate the proceedings.

SECTION 9. The decision of the executive committee in all matters pertaining to the interpretation and execution of the provisions of Sections 5, 6, and 7 of this article shall be final.

ARTICLE III. PUBLICATIONS

SECTION 1. The proceedings of the annual meeting and the papers presented at such meetings shall be published at the discretion of the executive committee in the Association *Bulletin* or in such other form as the executive committee may decide best meets the needs of the membership of the Association.

SECTION 2. The payment of annual dues for any fiscal year entitles the member or associate to receive without further charge a copy of the *Bulletin* of the Association for that year.

SECTION 3. The executive committee may authorize the printing of special publications to be financed by the Association from its general, publication, or special funds and offered for sale to members and associates in good standing at not less than cost of publication and distribution.

ARTICLE IV. REGIONAL SECTIONS, TECHNICAL DIVISIONS
AND AFFILIATED SOCIETIES

SECTION 1. Regional sections of the Association may be established provided the members of such sections are members of the Association and shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular annual meeting, an affirmative vote of two-thirds of the members present and voting being necessary for the establishment of such a section; and provided that the Association may revoke the charter of any regional section by a vote of two-thirds of the members present and voting at a regular annual meeting.

SECTION 2. Technical divisions may be established, provided the members interested shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular meeting, an affirmative vote of two-thirds of the membership present and voting being necessary for the establishment of such a division. In like manner, the Association may dissolve a division by an affirmative vote of two-thirds of the members present and voting at any annual meeting. A technical division may have its own officers, and it may have its own constitution and by-laws provided that, in the opinion of the executive committee, these do not conflict with the constitution and by-laws of the Association. The executive committee shall be empowered to make arrangements with the officers of the division for the conduct of the business of the division. A division may admit to affiliate membership in the division specially qualified persons who are not eligible to membership in the Association. Technical divisions may affiliate with other scientific societies, with the approval of the executive committee.

SECTION 3. Subject to the affirmative vote of two-thirds of the membership present and voting at an annual meeting, and with legal advice, the executive committee may arrange for the affiliation with the Association of duly organized groups or societies, which by objects, aims, constitutions, by-laws, or practice are developing the study of geology or petroleum technology. In like manner and with like advice, the executive committee may arrange conditions for dissolution of such affiliations. Affiliation with the Association need not prevent affiliation with other scientific societies. Members of affiliated societies who are not members of the Association, shall not have the privilege of advertising their affiliation with the Association on professional cards or otherwise.

ARTICLE V. DISTRICT REPRESENTATIVES

The executive committee shall cause to be elected district representatives from districts which it shall define by a local geographic grouping of the membership. Such districts shall be redesignated and redefined by the executive committee as often as seems advisable. Each district shall be entitled to one representative for each seventy-five members, but this shall not deprive any designated district of at least one representative. The representatives so apportioned shall be chosen from the membership of the district by a written ballot arranged by the executive committee. They shall hold office for two years, their term of office expiring at the close of the annual meeting.

ARTICLE VI. COMMITTEES

Appointment and Tenure

SECTION 1. There shall be the following standing committees: business committee; research committee; committee on geologic names and correlations; committee on applications of geology; committee for publication; finance committee; committee on statistics of exploratory drilling; trustees of revolving publication fund; trustees of research fund; medal award committee; and distinguished lecture committee.

The president shall appoint all standing committees except the business committee

and the medal award committee, for which provision is hereafter made. Members of all committees except the business committee shall serve for a three-year term, but in rotation, with one-third of the members being appointed each year. The president shall designate the chairmen, annually, shall have power to fill vacancies, and shall notify the members of the committees of their appointment. The president may designate one or more vice-chairmen annually.

In addition to the aforesaid standing committees, the executive committee shall appoint annually a nominating committee and its chairman, the president shall appoint annually a ballot committee, and annually or semiannually a resolutions committee, and such special committees as the executive committee may authorize. Special committees shall be appointed for a term of one year. The president shall designate the chairmen of such committees.

Business Committee

SECTION 2. The business committee shall act as a council and advisory board to the executive committee and the Association. This committee shall consist of the executive committee, not more than five members at large appointed annually by the president, two members elected by and from each technical division, and the district representatives. The president shall also appoint annually a chairman and a vice-chairman, but neither of these need be one of those otherwise constituting the business committee. The secretary-treasurer shall act as secretary of the business committee. If a district or technical representative is unable to be present at any meeting of the committee he may designate an alternate, who, in the case of a district representative, may or may not be a resident of the district he is asked to represent, and the alternate, on presentation of such a designation in writing, shall have the same powers and privileges as a regularly chosen representative. The business committee shall meet the day before the annual meeting at which all proposed changes in the constitution or by-laws shall be considered, all old and new business shall be discussed, and recommendations shall be voted for presentation at the annual meeting.

Research Committee

SECTION 3. The purpose of the research committee is the advancement of research, particularly within the field of petroleum geology. The committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Committee on Geologic Names and Correlations

SECTION 4. The purpose of the committee on geologic names and correlations is to lend assistance to authors on problems on stratigraphy and nomenclature and to advise the editor and executive committee in regard to the propriety of the use of stratigraphic names and correlations in papers submitted for publication by the Association. The committee shall consist of fifteen members unless a different number is authorized by the executive committee.

Committee on Applications of Geology

SECTION 5. The object of the committee on applications of geology is to advise and promote ways and means for informing the general public on all phases of geology particularly on the natural occurrence of oil and gas underground, the methods of searching for these substances, and the methods of exploiting them. The committee shall consist of twelve members unless a different number is authorized by the executive committee.

Committee for Publication

SECTION 6. The purpose of the committee for publication is to assist in securing desirable manuscripts for publication in the *Bulletin* or other publications of the Association.

The committee may also assist in securing papers for delivery at the annual meetings. The committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Finance Committee

SECTION 7. The finance committee shall act as financial advisers to the executive committee. The committee shall consist of three members. If a member of the finance committee should be elected to the executive committee he shall resign from the finance committee and the president shall appoint a member of the Association to complete his unexpired term.

Trustees of Revolving Publication Fund

SECTION 8. Before any publication project shall be undertaken with the use of the revolving publication fund the approval of the trustees and the executive committee must be secured. There shall be three trustees. If a trustee should be elected to the executive committee he shall resign as a trustee and the president shall appoint a member of the Association to complete his unexpired term.

Trustees of Research Fund

SECTION 9. Before any research work may be undertaken with the use of money from the research fund, the approval of the trustees and the executive committee shall be secured. There shall be three trustees. If a trustee shall be elected to the executive committee he shall resign as a trustee and the president shall appoint a member of the Association to complete his unexpired term.

Resolutions Committee

SECTION 10. The resolutions committee shall be charged with the duty of presenting at the annual and semi-annual meetings resolutions expressing the Association's appreciation and thanks to those who have worked and contributed to the success of the meetings.

Medal Award Committee

SECTION 11. The purpose of the committee shall be to choose recipients for all medals or other awards which may be established by the executive committee. The committee shall consist of nine members and three ex-officio members. The nine members of the original committee shall be appointed by the president, three of whom shall serve for three years, three for two years, and three for one year. One of each of the groups appointed for the different lengths of time shall be a former president of the Association. Each incoming president shall thereafter appoint three members of the committee to serve for three years, one of which shall be a former president of the Association. Vacancies on the committee due to resignation or other causes shall be immediately filled by the president. The ex-officio members shall be: (1) the president of the Association, (2) the president of the Society of Exploration Geophysicists, (3) the president of the Society of Economic Paleontologists and Mineralogists. The president of the Association shall be the chairman of the committee, unless he shall, at his election, name a chairman to serve for one year.

Committee on Statistics of Exploratory Drilling

SECTION 12. The function of the committee on statistics of exploratory drilling shall be to assemble and compile statistics on the methods used to locate exploratory wells and on the results of exploratory drilling for oil and gas, and annually to submit for publication in the *Bulletin* a report summarizing and analyzing these data. This committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

ASSOCIATION ROUND TABLE

Distinguished Lecture Committee

SECTION 13. The purpose of the distinguished lecture committee is to arrange, conduct, and manage a series of self-sustaining, non-profit lecture tours among affiliated societies and Association sections by outstanding speakers on timely subjects. The committee shall consist of seven members unless a different number is authorized by the executive committee.

Nominating Committee

SECTION 14. The purpose of the nominating committee is to nominate candidates for the Association offices as provided in the constitution. The committee shall consist of a chairman and four other members appointed by the executive committee to serve one year. At least two members of the nominating committees shall be past officers of the Association.

Ballot Committee

SECTION 15. The function of the ballot committee is to count the ballots received in the regular annual election and to report the final results to the president. A preferential form of ballot shall be counted in the following manner. The ballot committee shall count first-choice votes only. If no candidate receives a majority, the candidate with the fewest votes shall be eliminated and the second choice on his ballots shall be counted as first choice for the remaining candidates. The committee shall continue this procedure until one candidate has a majority.

ARTICLE VII. AMENDMENTS

These by-laws may be amended by vote of three-fourths of the members present and voting at any annual meeting, provided that such changes shall have been recommended to the meeting by the business committee and provided that their legality shall be determined by the executive committee prior to publication.

MEMORIAL

ROBERT WATSON CLARK (1884-1948)

Robert Watson Clark was born on a farm near West Branch, Michigan, August 17, 1884, the son of Francis and Louisa Figg Clark. Death occurred on June 5, 1948, at his home in Arcadia, California. Bob enjoyed perfect health throughout his life until November, 1947. He underwent an operation in December after which his health apparently improved to such an extent he was able to resume his geological duties to a limited degree. This condition continued until late in March when he suddenly became worse and from thence on was confined to his home.

Bob began to develop the quality of self reliance at an early age due to the death of his mother when he was only five years old, followed by his father's death twelve years later. During these early years, he and his sister, Grace, lived with an uncle, Erastus W. Clark, until Bob graduated from the West Branch Junior High School as valedictorian of his class. He then made his home with an aunt, Mrs. T. A. Holmes in Flint, Michigan, where he completed his high-school education in 1902. To earn money for his college education he taught in country schools for two years and worked at odd jobs during the summers.

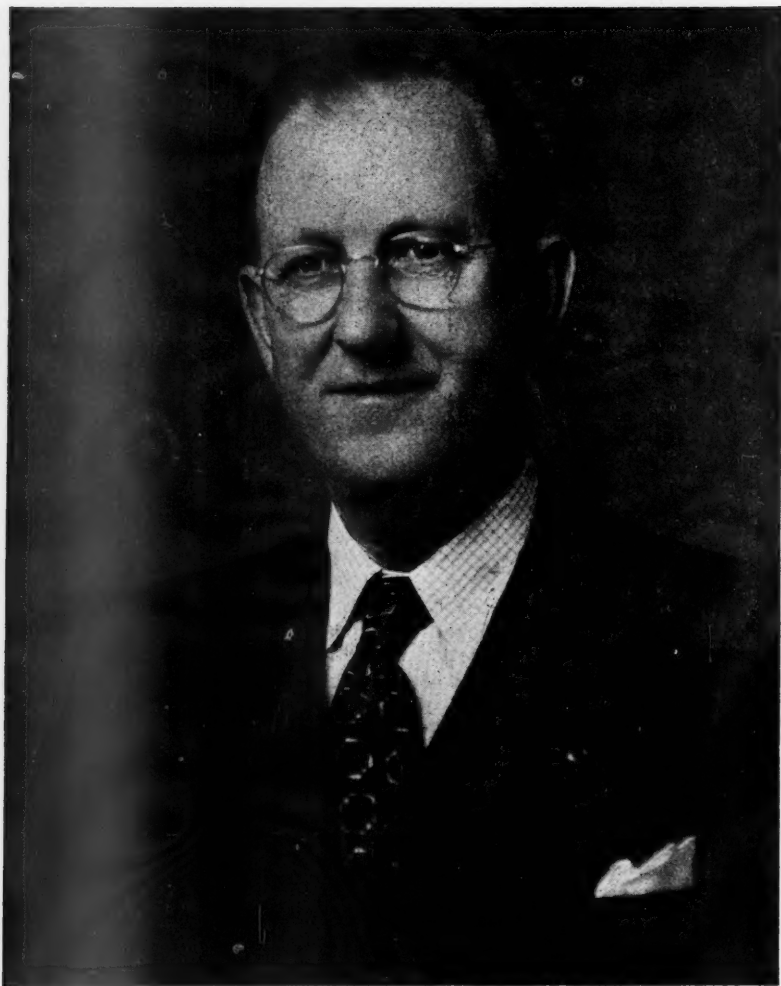
He enrolled in the University of Michigan in 1904, majoring in geology, and in his junior year became technical assistant in the mineralogical laboratory. Upon receiving his A.B. degree in the spring of 1908, he immediately departed for Germany and spent the following year at the University of Munich studying petrographic methods under Ernst Weinschenk. He later studied at Heidelberg under Victor Goldschmidt.

In the fall of 1909, Bob again returned to the University of Michigan where he accepted an instructorship in mineralogy. Having been impressed with the value of Weinschenk's methods in teaching petrography, he made arrangements with his former instructor at Munich to translate Weinschenk's two text books on this subject. The translation was published in a single volume in 1912. In addition to this, he wrote a number of papers on mineralogical subjects while at this university.

During the summers of 1910 and 1911, Bob worked for the State Geological Survey of Michigan as field party chief, making magnetometer surveys of iron ore deposits. The following year he received his M.A. degree from the University of Michigan. The summers of 1913 and 1914, Bob acted as field party chief on iron ore surveys for the State Geological Survey of Wisconsin.

Bob resigned his position at the University in 1916, to accept an assignment as field geologist with the Cosden Oil Company in Oklahoma until 1917, when he became associated with the firm of Pemberton and Severy. This work took him to Eldorado and Iola, Kansas, and finally to Okmulgee, Oklahoma, where he formed a partnership with C. Max Bauer in January, 1919. The oil business was booming at this time and the new firm was immediately swamped with work. Among their many outstanding reports were those which led to the discovery of the Deaner and Jameson pool and the greater Seminole oil field.

In October, 1921, Bob bought out Bauer's interest in the consulting business. During the following years, his activities covered a large area and many types of geologic work, the results of some of which have been published as bulletins of the Oklahoma Geological Survey. Bob also found time to do the necessary work leading to his Ph.D. degree which was taken at the University of Michigan in 1924. While engaged in consulting practice, he developed a sense of proportion between the value of geology and executive management in



ROBERT WATSON CLARK

the oil business which, with his innate sense of fairness and cooperation, was to prove invaluable to him in later years.

In May, 1928, Bob undertook consulting work for the Gypsy Oil Company in Colorado and New Mexico. A year later he was transferred to the head office of the Gulf Oil Corporation in Pittsburgh as director of geological research and consultant to the geophysical research department.

In January, 1938, Bob was sent to Los Angeles to become chief geologist of the Western Gulf Oil Company, which position he held until the time of his death. Under his guidance, the company enjoyed the distinction of discovering several new oil fields, the most notable of which was Paloma.

Bob became a member of the American Association of Petroleum Geologists in 1918. He was vice-president in 1943, program chairman of the national meeting held in Los Angeles, 1947, and trustee of the research fund at the time of his death. He was a member of the American Institute of Mining and Metallurgical Engineers, and a fellow in the Geological Society of America. He served on the membership committee of this latter society from 1946 to 1948. He was also a member of the American Geophysical Union, the Society of Exploration Geophysicists, Sigma Xi, and the Branner Club, a local geological society.

Bob's private life was principally devoted to his family. While in Okmulgee, he and Mrs. Clark were responsible for the establishment of the First Unitarian Church in that city. He also served as president of the local American Red Cross, president of the Parent Teacher's Association, president of the State Parent Teacher's Association, and state chairman of the committee sponsoring a colored Parent Teacher's Association. He was a member of the Chamber of Commerce and the Lions Club. In Los Angeles, he was a member of Town Hall, the University Club, and the Metropolitan Club. He and his family were members of the Neighborhood Church of Pasadena.

On September 23, 1911, he married Mary Jessie Wood, at Ann Arbor, Michigan. Surviving him are Mrs. Clark, and three children, Grace May Clark, Jane Griswold Clark Pierce, and Robert Lester Clark.

Thus, in memoriam, we review the life of Doctor Robert Watson Clark—a scientist, and always a friend. His lifetime represents sixty-three years of useful endeavor, rich in accomplishment. His character evidences a man of sterling worth. He was possessed of a fine sense of humor, unquestioned integrity, a keen interest in life, one who has lived—and lived abundantly. His friendly personality, his smile, and helpful council were a source of understanding and admiration. And so it is, we pay homage to our comrade and friend, who will live always in our memories and our hearts.

WAYNE LOEL

Carson City, Nevada
September 13, 1948

AT HOME AND ABROAD

NEWS OF THE PROFESSION

WINTHROP P. HAYNES, retired from the Standard Oil Company (New Jersey) after many years in Standard service in this country and abroad, is now visiting lecturer on petroleum geology at Harvard University for 3 days each week and amateur farmer at his country home at Boxford, Massachusetts, the remainder of each week.

R. P. SWIRCZYNSKI, of the Sohio Petroleum Company, spoke on "The Geology of the Northwest Sulphur Pool, Murray County, Oklahoma," at the luncheon meeting of the Tulsa Geological Society, November 5.

EDWARD C. SIMPSON has opened his office in consulting geology at Casper, Wyoming.

EARL M. BURCH has left the Stanolind Oil and Gas Company at Shreveport, Louisiana, to become district geologist for the El Dorado Refining Company at Wichita, Kansas.

JOSEPH STEWART MARTIN has changed his business affiliation from the Tide Water Associated Oil Company to the Intex Oil Company, Dallas, Texas.

J. W. CRAIG, formerly with the Gulf Oil Corporation, is associated with BASIL B. ZAVOICO, City National Bank Building, Houston, Texas.

OTTO HACKEL has left the Tide Water Associated Oil Company to join the Independent Exploration Company, at Bakersfield, California.

STERLING E. LITTLE is in the geological department of the Kerr-McGee Oil Industries, Inc., at Morgan City, Louisiana.

HAROLD E. JONES is no longer with BASIL B. ZAVOICO. He is in the employ of the Stanolind Oil and Gas Company, Midland, Texas.

JOHN E. BRANTLY, JR., may be addressed at Caixa Postal 40, Salvador, Bahia, Brazil.

FRANK T. WHITTINGHILL, JR., resigned as geologist for Bell Brothers of Robinson, Illinois, and is now engaged in consulting work and associated with Joe C. Arvin of the Arvin Drilling Company, Robinson, Illinois.

The 15th annual Engineer's Day of the Colorado School of Mines will be held in Golden, Colorado, on Friday, April 22, 1949. Exhibition space, both indoors and out, is available, free of charge, to all industries engaged in or related to the discovery, extraction, and refining of minerals and petroleum. Information may be obtained by writing J. Robert Medaris, chairman of the Engineering Day Committee, Golden, Colorado.

DAN F. KRALIS has been president and chief geologist of the Petroleum Exploration Company since July 9, with headquarters at Eastland, Texas.

EUGENE HOLMAN, president of the Standard Oil Company (New Jersey), received the distinguished service award for major oil company executives, at the Fort Worth meeting of the Texas Mid-Continent Oil and Gas Association.

W. E. WRATHER, director of the United States Geological Survey, received the Texas Mid-Continent Oil and Gas Association distinguished service award for independent oil operators. Presentation was made by WALLACE E. PRATT, retired vice-president of the Standard Oil Company (New Jersey). Both are former presidents of the A.A.P.G.

D. R. SNOW, of the Barnsdall Oil Company, Tulsa, Oklahoma, is newly elected treasurer of the Independent Petroleum Association of America.

LLOYD M. PYEATT has changed his company connection from the Atlantic Refining Company to the Sohio Petroleum Company, Houston, Texas.

STEWART H. FOLK has resigned his position as technical adviser to the Officer in Charge, Naval Petroleum No. 4, in order to accept an associate professorship of geology at Baylor University.

JACK R. HUFFMYER has moved from the Standard Oil Company of Texas to the American Republics Corporation, Box 547, Artesia, New Mexico.

SAM M. PENA has left the Petty Geophysical Engineering Company to join the Taylor Exploration Company, Houston, Texas.

GLENN W. SANDBERG has resigned from the Arkansas Fuel Oil Company. He is geologist in the San Antonio, Texas, office of the Sunray Oil Corporation.

HOWARD A. GIBSON has left the employ of the Pan American Production Company in Houston to join the Chicago Corporation as geologist in Corpus Christi, Texas.

C. L. MOODY, editor of the Association *Bulletin*, attended the International Geological Congress, in London in August and September, as an A.A.P.G. official delegate. He talked about his impressions and experiences at the meeting of the Shreveport Geological Society at the Caddo Hotel, Shreveport, Louisiana, October 12.

DIRECTORY OF FILMS AND SLIDES

A booklet entitled *Directory of Films and Slides of Possible Interest to Geologists*, prepared by HELGE E. HANSEN, Audio-Visual Education Center, University of Michigan, Ann Arbor, and KENNETH K. LANDES, who was chairman of the A.A.P.G. committee on applications of geology, 1947-1948, has been published by the Association and is available upon request directed to A.A.P.G. Headquarters, Box 979, Tulsa 1, Oklahoma. This is a 22-page, lithoprinted, 8½ × 11-inch paper-covered publication.

PAUL W. NETTERSTROM has resigned from his position as Rocky Mountain geologist with the Barnsdall Oil Company and is engaged in independent geologic research and consulting in Casper, Wyoming.

ARTHUR C. MCFARLAN, head of the geology department at the University of Kentucky, is director of the Kentucky Geological Survey in charge of policy and obtaining appropriations from the State legislature. DANIEL J. JONES continues as State geologist in charge of office and field work.

New officers of the Wyoming Geological Association, Casper, Wyoming, are: president, JED B. MAEBIUS, Gulf Oil Corporation; first vice-president, EMMETT E. SCHIECK, Sohio Petroleum Company; second vice-president, DONALD E. EDSTROM, Sinclair Wyoming Oil Company; secretary, J. B. HEADLEY, JR., Atlantic Refining Company; treasurer, GEORGE L. GOODIN, Petroleum Information, Inc.

L. T. BARROW, a director and vice-president of the Humble Oil and Refining Company, Houston, Texas, has been elected chairman of the board of directors. He joined the Humble geological department in 1924. He was chief geologist from 1929 to 1937, when he was elected to the board of directors. In 1938 he was made a vice-president.

G. WENDELL SMITH, of the Magnolia Petroleum Company, San Antonio, Texas, spoke on "The Geology of Jouranton Field, Atascosa County," at the monthly meeting of the South Texas A.A.P.G. Section, November 18.

R. A. SHELLEY has left the Sunray Oil Corporation to enter the employ of the Bay Petroleum Corporation at Wichita, Kansas.

JACKSON B. SPARKS is engaged in independent consulting geology at 237 Woods Avenue, Newark, Ohio.

WILLIAM E. HUMPHREY has been transferred from the Phillips Oil Company to the post of assistant chief geologist of the Phillips Colombian Oil Company with headquarters in Bogota.

MARTIN G. EGAN has accepted a position as geologist with the Superior Oil Company in the Midland, Texas, district. He is no longer engaged in consulting geology in Evansville, Indiana.

J. W. PORTER recently left the staff of the Department of Natural Resources of the Province of Saskatchewan and has accepted a position on the geological staff of the Rio Bravo Oil Company of Calgary, Alberta.

JOE NETICK, who for 3 years has been resident manager of the Orinoco Oil Company, a subsidiary of the Pure Oil Company in Venezuela, has been spending his vacation at his home in Del Rio, Texas. He started work for the Orinoco Oil Company in Venezuela in 1922 and is now regarded as dean of the geological fraternity in the Maracaibo basin. His work in the District of Mara, west of Maracaibo, led to the discovery of the Netick field in 1932. It was in this area that the Orinoco Oil Company drilled a deep test last year.

E. W. FOSSHAGE, chief geologist of the Shamrock Oil and Gas Corporation, Amarillo, Texas, reports the recent employment of JOHN S. GIELING in the exploration department of the company. Gieling recently graduated in geology at Harvard University.

W. E. WRATHER, director of the Geological Survey, Department of the Interior, has been named chairman of a committee on geophysics and geography by KARL T. COMPTON, chairman of the Research and Development Board, National Military Establishment. The newly formed committee is a merger of the committee on geophysical sciences and the committee on geographical exploration, two units of the Research and Development Board. The group will study problems within the scope of the earth sciences, including weather and climate, strategic minerals, water supplies and contamination, studies of the ocean, its circulation, and structure of the ocean floor. Additional members of the committee include SAMUEL B. MORRIS, general manager and chief engineer of the department of water and power, Los Angeles; HORACE BYERS, department of meteorology, University of Chicago; P. E. JAMES, professor of geography, Syracuse University; and RICHARD JOEL RUSSELL, chairman, department of geography, Louisiana State University, Baton Rouge, Louisiana.

LLOYD CHARLES PRAY is a National Research Council pre-doctoral fellow in geology at the California Institute of Technology, Pasadena, California.

ROUSE SIMMONS is president of the Republic Petroleum Company and its subsidiaries, operating in California, Wyoming, Colorado, and New Mexico. His address is 811 West Seventh Street, Los Angeles, California.

President PAUL WEAVER of Houston, Texas, past-president C. E. DOBBIN of Denver, Colorado, and secretary-treasurer J. V. HOWELL of Tulsa, Oklahoma, held an informal meeting of the A.A.P.G. executive committee while in New York City attending the meeting of the Geological Society of America, November 11-13.

J. HARLAN JOHNSON, professor of geology, Colorado School of Mines, Golden, Colorado, talked on "Highlights of the Recent International Geological Congress Held in England," at a meeting of the Rocky Mountain Association of Geologists at Golden, November 19.

At a dinner meeting of the Shreveport Geological Society, the A.I.M.E. East Texas Section, and the Ark-La-Tex Geophysical Society, November 15, at the Caddo Hotel, Shreveport, Louisiana, ROBERT L. SUGGS, president of Off Shore Navigation, Inc., discussed "Shoran Surveying."

A. ALLEN WEYMOUTH, with experience of 10 years as a petroleum geologist in the Middle East, New Zealand, and Venezuela, has been appointed chief geologist for the newly incorporated American Independent Oil Company of San Francisco. During the last 2 years he was development geologist for the Standard Oil Company of Texas, with headquarters at Houston. He will serve as an executive assistant and consultant to NATE P. ISENBERGER, formerly of the Phillips Petroleum Company, and now vice-president of the American Independent in charge of foreign exploration.

The Geological Forum of the Pacific Section of the Association presented the following program, at the California Institute of Technology, Pasadena, November 15: "The Big Pine Fault," by THOMAS DIBBLEE, Richfield Oil Corporation; "Geology of the Western End of Antelope Valley," by JOHN WIESE, Richfield Oil Corporation; "Comments on the Recent International Geologic Congress, London" (illustrated), by IAN CAMPBELL, California Institute of Technology; and "Wanderings in Egypt," illustrated with kodachrome slides, by V. L. VANDER HOOFF, Stanford University.

LAURENCE BRUNDALL, vice-president of Geophoto Service, Denver, Colorado, discussed "Photogeology," at the noon meeting of the Tulsa Geological Society, November 12.

JOHN C. MAHER, senior geologist, Fuels Section, United States Geologic Survey, spoke on "The Pre-Pennsylvanian Geology of the Hugoton Embayment of the Anadarko Basin," at the technical meeting of the Tulsa Geological Society, November 15.

EDWARD N. JONES, consulting engineer of Pettus, Texas, talked on "Acidization of Wilcox and Jackson Sand in Bee County, Texas," before the Houston Geological Society, November 8.

CARL E. JOHNSON, consulting geologist, is situated at 4215 South Presa, San Antonio, Texas.

JAMES D. MCLEAN, JR., has temporarily moved his consulting office in micropaleontology to the Virginia Military Institute, Lexington, Virginia, where he is acting head of the department of geology.

CECIL V. HAGEN, consulting geologist, spoke on "The Geology of the Coast of Ecuador," at the meeting of the Houston Geological Society, November 22.

ROBERT McMILLAN, of Geophoto Services, Denver, Colorado, should be given credit for the use of the photographs reproduced on page 2178 of the November *Bulletin*, illustrating the Wyoming Geological Association field trip last summer.

WILLIAM HARVEY EMMONS died, November 5, at the age of 71 years. He was an honorary member of the A.A.P.G. He was head of the department of geology and director of the Minnesota Geological Survey from 1911 until retirement in 1944.

JAMES SMITH STEWART, geologist with the Canadian Geological Survey, Ottawa, died in November, at the age of 67 years.

SYLVAIN J. PIRSON is joining the engineering department of the Stanolind Oil and Gas Company in Tulsa, Oklahoma, in January. He has been for many years in the School of Mineral Industries at the Pennsylvania State College.

New officers of the New Orleans Geological Society are: president, FRED S. GOERNER, California Company; vice-president, M. N. BROUGHTON, The Texas Company; secretary-treasurer, H. A. NYSTROM, Schlumberger Well Surveying Corporation, 452 Canal Building, New Orleans, Louisiana.

The second fall meeting of the Eastern Section of the A.A.P.G. was held at the Mining Club, New York City, November 18, with 28 members and 11 visitors present. HOLLIS D. HEDBERG presided and G. F. KAUFMANN acted in his capacity as secretary. PAUL RUEDEMANN, recently returned to this country, described his imprisonment by Roumanian communists. G. F. KAUFMANN showed a film, "Search for Oil in Papua and New Guinea," and H. E. V. BANDET showed one on "India and Netherlands New Guinea."

CEVAT E. TASMAN presided at the semi-annual meeting of the Geological Society of Turkey in Ankara, October 25-27. A paper on Hazro, 50 kilometers north of Diyarbakir, described NECIP TOLUN's study of a geological section extending from the bituminous sands of the Devonian to the Upper Tertiary.

The delegates of eleven societies met in Washington, D. C., November 15-16, and elected. A. I. LEVORSEN, president; H. B. HEROV, vice-president; and EARL INGERSON, secretary-treasurer, of the newly organized American Geological Institute. The societies composing the membership of the new institute are: Geological Society of America, American Association of Petroleum Geologists, American Institute of Mining and Metallurgical Engineers, American Geophysical Union, Mineralogical Society of America, Society of Economic Geologists, Society of Exploration Geophysicists, Society of Economic Paleontologists and Mineralogists, Seismological Society of America, Paleontological Society, and Society of Vertebrate Paleontology.

J. STEWART WILLIAMS, of the Utah State Agricultural College, spoke on "Major Elements of Utah Geology and the Current Exploration Program," at a dinner meeting of the Rocky Mountain Association of Geologists, at Denver, December 3.

BASIL V. SAVOY has changed company affiliation. Formerly with the Central Pipe Line Company, he is now in the employ of the Continental Oil Company, Houston, Texas.

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa 1, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

- Roy F. Beery, Jr., Kilgore, Tex.
 J. M. Bugbee, Harold F. Pierce, R. R. Eckart
 Ward William Dunn, Denver, Colo.
 Burton E. Ashley, Don G. Vieaux, Joseph H. Turner
 Beverly Custis Diggs Edwards, Oklahoma City, Okla.
 R. A. Conkling, Albert S. Clinkscales, Gerald C. Maddox
 Joseph Edward Headington, Dallas, Tex.
 Keith L. Rathbun, Ira H. Stein, Claude C. Albritton, Jr.
 Betty Kellett Nadeau, Webster Groves, Mo.
 Walter A. Ver Wiebe, Dollie Radler Hall, E. A. Wyman
 Anthony Edward Lloyd Morris, Bakersfield, Calif.
 C. M. Wagner, Peter H. Gardett, William D. Lewis
 Everett Wilfred Pease, Oildale, Calif.
 Downs McCloskey, W. D. Kleinpell, James Gilluly
 Fred B. Phleger, Jr., Amherst, Mass.
 Henry C. Stetson, Parker D. Trask, Shepard W. Lowman
 Edmund Lee Thackrey, Midland, Tex.
 C. F. Henderson, R. V. Hollingsworth, Ronald K. DeFord

FOR ASSOCIATE MEMBERSHIP

- Carlos Junior Barkley, Carlsbad, N. Mex.
 H. M. Goodman, H. W. Scott, J. L. Hough
 Richard Kuno Blankennagel, Tunis, Tunisia
 Robert Beall, Maurice H. Wallace, M. A. Dresser
 Jack Gordon Blythe, Wichita, Kan.
 W. A. Ver Wiebe, J. R. Berg, Edward C. Dapples
 William Hamilton Bourne, Bakersfield, Calif.
 F. G. Tickell, A. I. Levorsen, S. W. Muller
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ERRATA

- P. 20, Table I, Colorado County, line 1, column 4, should read: 8,256-8,316.
P. 20, Table I, footnote, last line, should read: 1939-1946.
P. 22, Table I, Live Oak County, Coquat field, line 2, column 4, should read: 7,542-48.
P. 22, Table I, San Jacinto County, Mercy field, line 1, column 4, should read: 8,209-89.
P. 23, Table I, Wilson County, Poth field, column 4, should read: 4,082-96.
P. 23, Table I, Allen Parish, So. Oberlin field, column 3, delete: 8,442?
P. 24, Table I, La Salle Parish, Olla field, line 3, column 4, should read: 2,768-75.
P. 32, References, line 21: an asterisk should precede Foster.
P. 32, References, lines 24 and 27, delete: asterisks preceding Cravell and Houston Geological Society.
P. 33, line 1, delete: asterisk.
P. 33, line 8, "Vol. 24" should read: Vol. 25.
P. 760, 1st full paragraph, line 9. For "Figure 4b" read: Fig. 12 B.
P. 1105, line 5 from bottom. For "on a seismograph location," read: as a result of surface geological mapping.
P. 1117, in table, *Sinu Basin*, Tablon 1: Instead of "Abandoned," read: Completed 13,000 MCF of gas.
P. 1117, in table, *Sinu Basin*, San Andres 1. Companies interested should be: Cities Service-Sinclair-Richfield.
P. 1169, last full paragraph, line 6. For "\$0.569" read: \$0.659.

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of the

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JANUARY—DECEMBER 1948

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ERRATA

- P. 1239, line 8. For "law barometer," read: low barometer.
- P. 1251, 3d paragraph, last line. For "less soluble" read: most soluble.
- P. 1253, "*Heterostegina*" should read: *Heterostegina*.
- P. 1293, in list of references and names insert:
 1928 R. A. Liddle (35). Alley's Creek beds and Godineau River marls.
 1936 H. G. Kugler (31). Part of Morne Diablo formation. "Lower green clays," Princes Town marls, Alley Creek formation.
- For the reference "1936 H. G. Kugler (33)," read: 1939 H. G. Kugler (33).
- P. 1998, next to last paragraph, first line. For "Oklahoma east-west line," read: Oklahoma east of west line.
- P. 1999, 3d paragraph from end. For "(thus including Ponca City, Pawnee . . .)" read: (but excluding Ponca City and including Pawnee . . .)

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Meetings will be announced. Visiting geologists and friends are welcome.

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Sinclair Prairie Oil Company
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Stanolind Oil and Gas Company

Regular Meetings: 7:30 P.M., Geological Room, University of Wichita, first Tuesday of each month. Noon luncheons, first and third Monday of each month at Wolf's Cafeteria. The Society sponsors the Kansas Well Log Bureau, 412 Union National Bank Building, and the Kansas Well Sample Bureau, 137 North Topeka. Visiting geologists and friends welcome.

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Vice-President and Program Chairman M. N. Broughton
The Texas Company, 1500 Canal Building
Secretary-Treasurer H. A. Nystrom
Schlumberger Well Surveying Corporation
452 Canal Building

Meets the first Monday of every month, October-May, inclusive, 12 noon, St. Charles Hotel. Special meetings by announcement. Visiting geologists cordially invited.

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Amerada Petroleum Corporation
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Magnolia Petroleum Company, Box 872
Treasurer Philip R. Allin
Gulf Oil Corporation

Meetings: Dinner and business meetings third Tuesday of each month at 7:00 P.M. at the Majestic Hotel. Special meetings by announcement. Visiting geologists are welcome.

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Consultant, Box 2571, West Jackson

Meetings: First and third Thursdays of each month, from October to May, inclusive, at 7:30 P.M., The Creole Room, LeFleur's Restaurant, Jackson, Mississippi. Visiting geologists welcome to all meetings.

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918 Hales Building
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Meetings: Technical program each month, subject to call by Program Committee, Oklahoma City University, 24th Street and Blackwelder. Lunches: Every second and fourth Thursday of each month, at 12:00 noon, Y.W.C.A.

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Schlumberger Well Surveying Corporation
Box 92

Meets monthly, September to May, inclusive, in the State Exhibit Building, Fair Grounds. All meetings by announcement.

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Dinner meetings will be held at 7:00 P.M. on the first Wednesday of every month from October to May, inclusive, at the Ardmore Hotel.

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Box 1007, Shawnee
Secretary-Treasurer Marcelle Mousley
Atlantic Refining Company, Box 169
Shawnee

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Consultant, 1510 Philtower Building
Editor - - - - - John C. Maher
U. S. Geological Survey
Federal Building

Meetings: First and third Mondays, each month,
from October to May, inclusive, at 8:00 P.M.,
University of Tulsa, Lorton Hall. Luncheons:
Every Friday (October-May), Chamber of Com-
merce Building.

PENNSYLVANIA

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Box 1939

Meetings: 2d Thursday of each month, 7:30 P.M.,
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Secretary-Treasurer - - - - - James D. Burke
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Regular luncheons, every Thursday, Terrace Annex
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meetings by announcement.

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Stanolind Oil and Gas Company
Box 660

Luncheons: Each week, Monday noon, Blackstone
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Evening meetings and programs will be an-
nounced. Visiting geologists and friends are
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Stanolind Oil and Gas Company
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Secretary-Treasurer - - - - - Millicent A. Renfro
Texas Pacific Coal and Oil Company, Box 2100

Meetings: Luncheon at noon, Hotel Texas, first
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ogists and friends are invited and welcome at
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ings write or call the secretary.

TEXAS

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Secretary-Treasurer - - - - Ralph H. McKinley
Panhandle Producing and Refining Company,
Box 1191

Meetings: Luncheon 1st and 3d Wednesdays of each month, 12:00 noon, Y.W.C.A. Evening meetings by special announcement. Visiting geologists and friends are cordially invited to all meetings.

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Secretary-Treasurer - - - - Maurice E. Forney
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1728 Milam Building

Meetings: One regular meeting each month in San Antonio. Luncheon every Monday noon at Milam Cafeteria, San Antonio.

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Editor - - - - W. T. Ziebold
Thomas Circle Road, Charleston, W.Va.

Meetings: Second Monday, each month, except June, July and August, at 6:30 P.M., Daniel Boone Hotel.

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Vice-President - - - - L. B. Fugitt
Stanolind Oil and Gas Company, Box 2089
Secretary-Treasurer - - - - Fred S. Alexander
Standard Oil Company of Texas, Box 2087

Meetings: Luncheon 1st and 3rd Wednesdays of each month, 12:00 noon, Herring Hotel. Special night meetings by announcement.

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Treasurer - - - - - Jane M. Johnson
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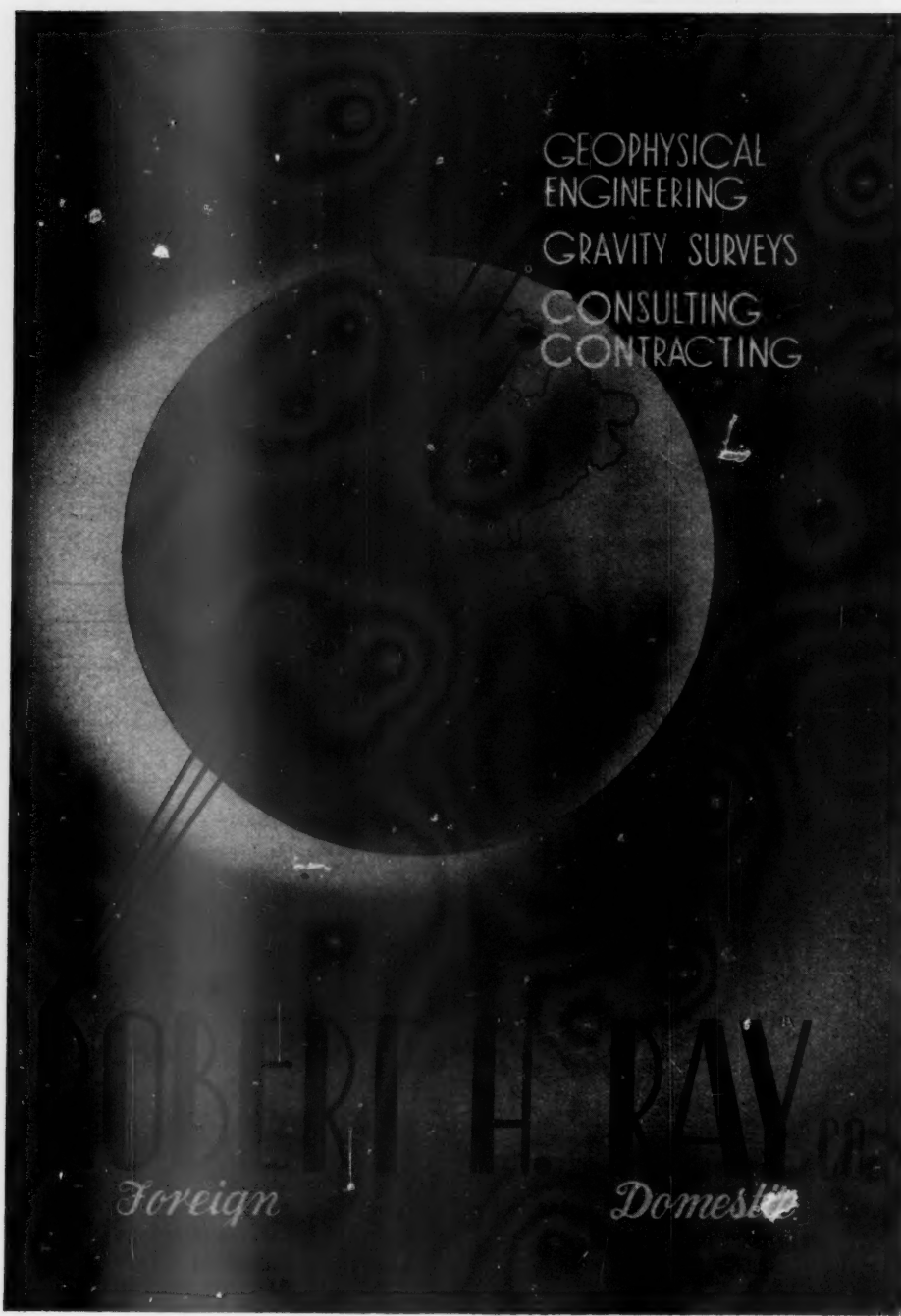
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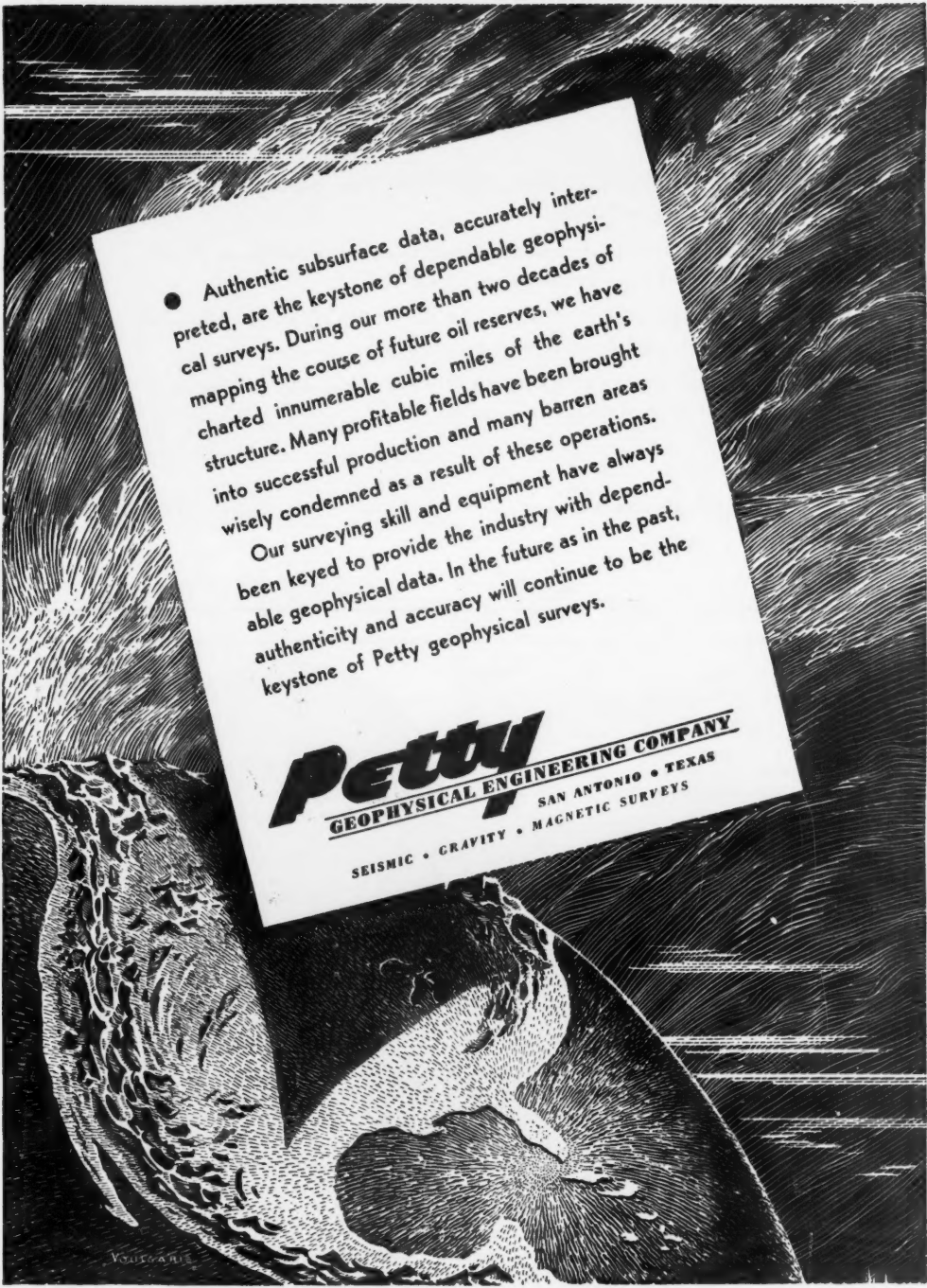
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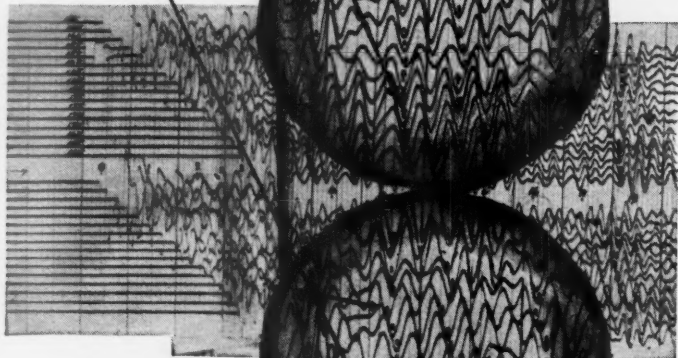
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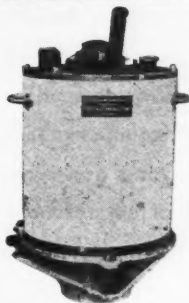
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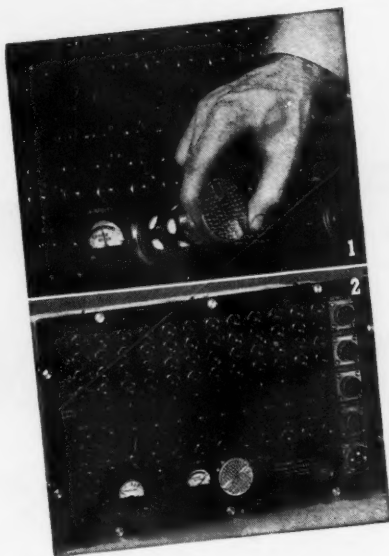


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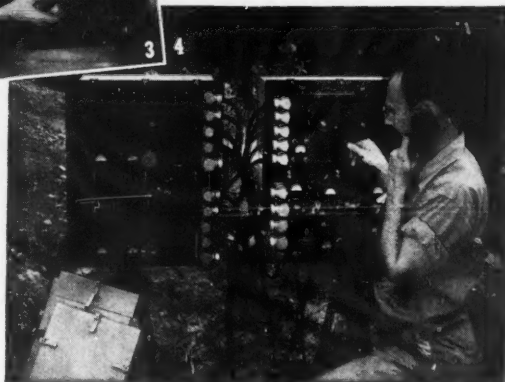
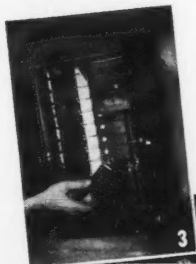
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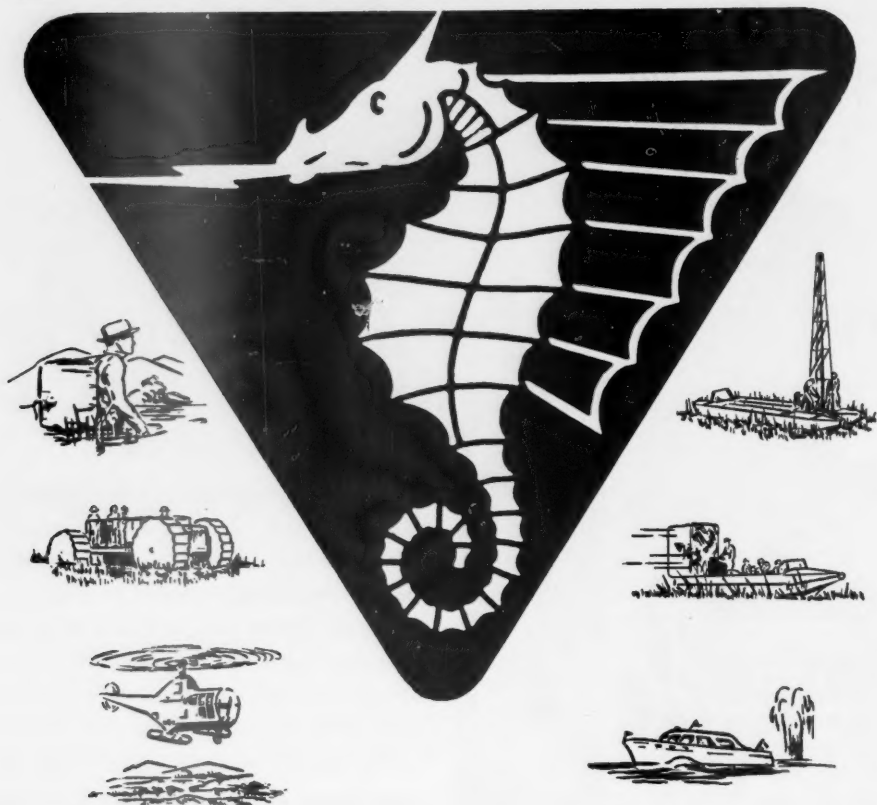
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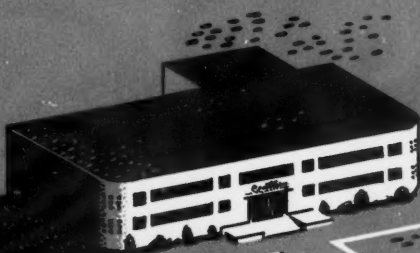
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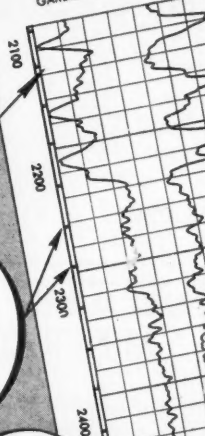
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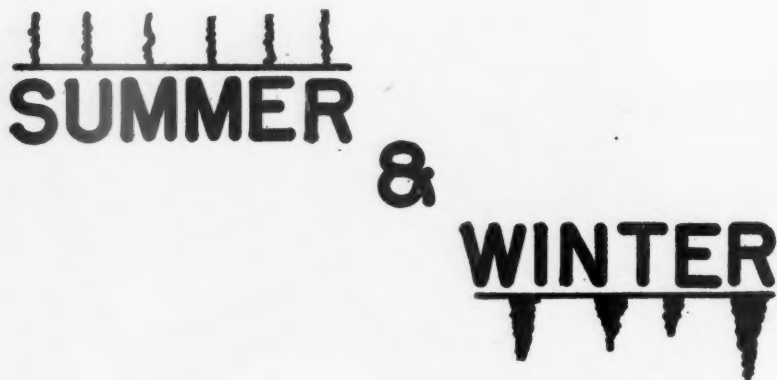
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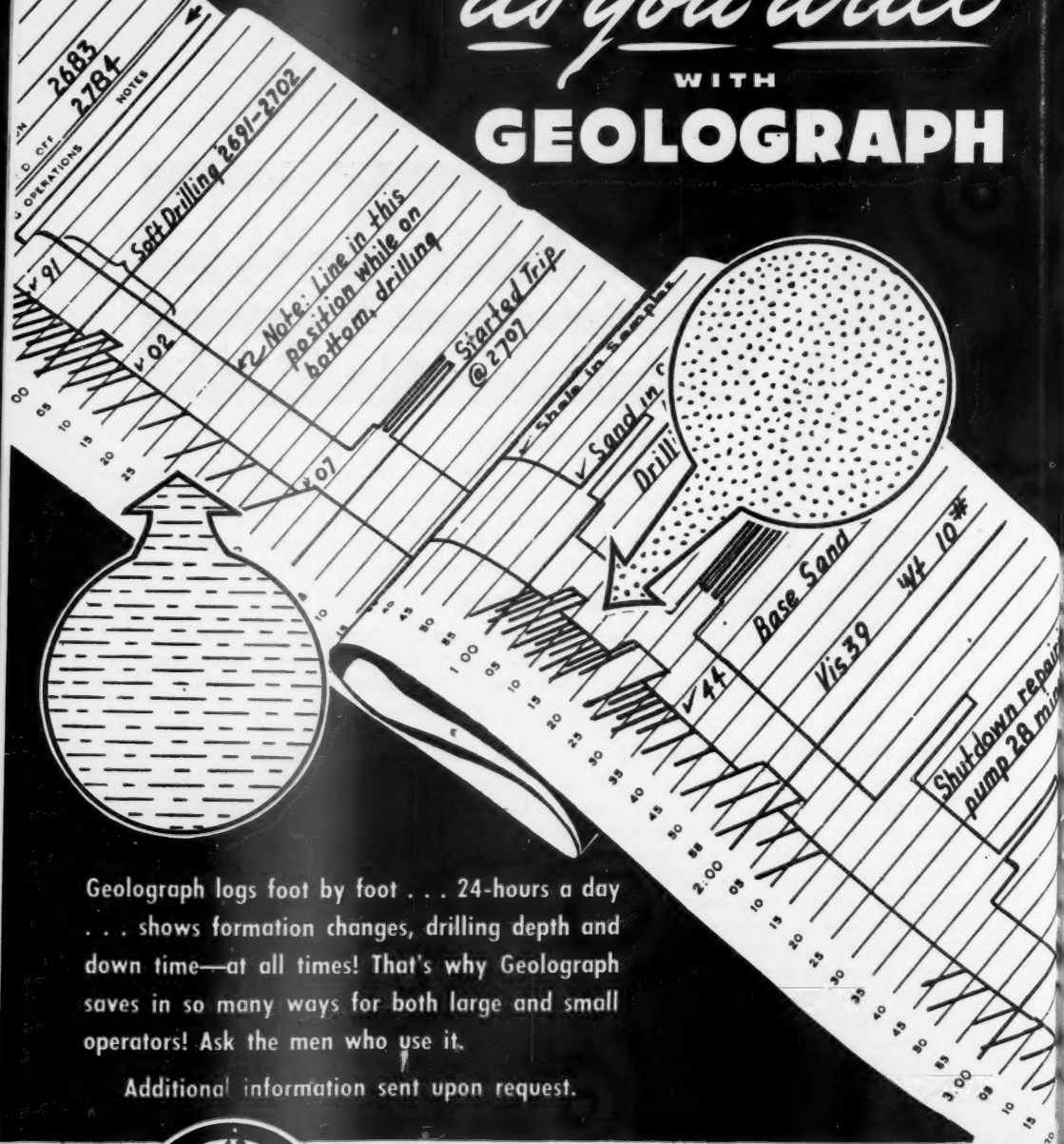
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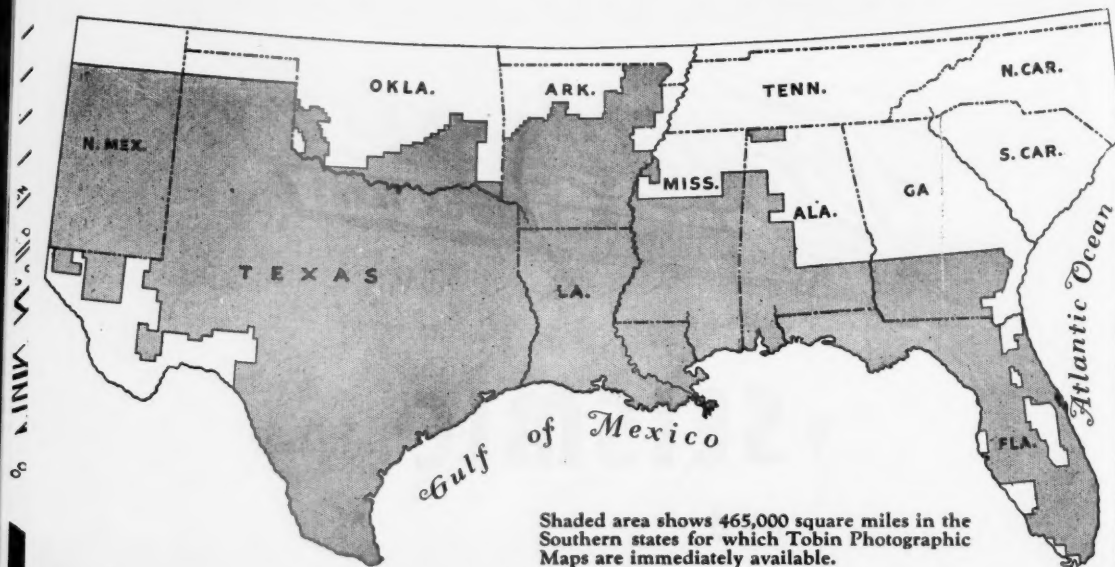
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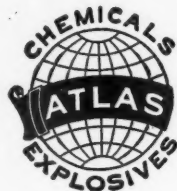
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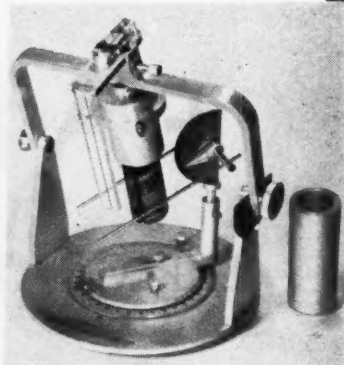
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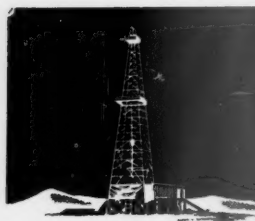
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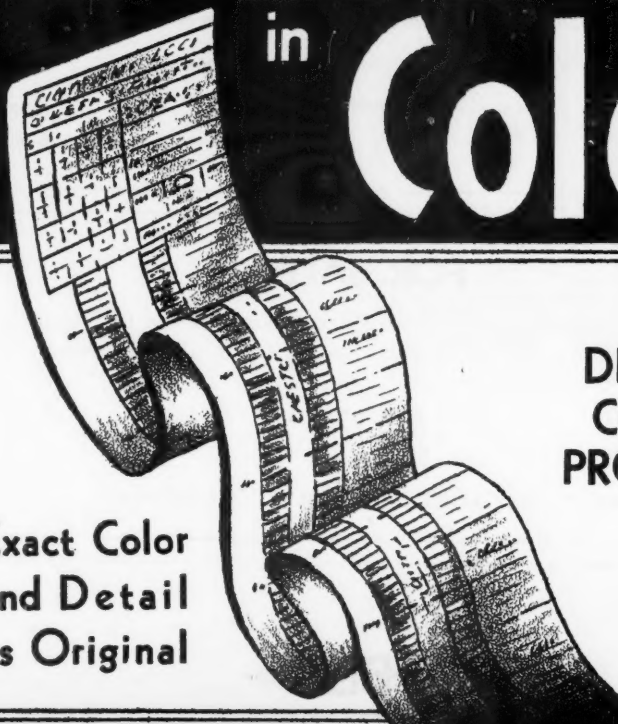


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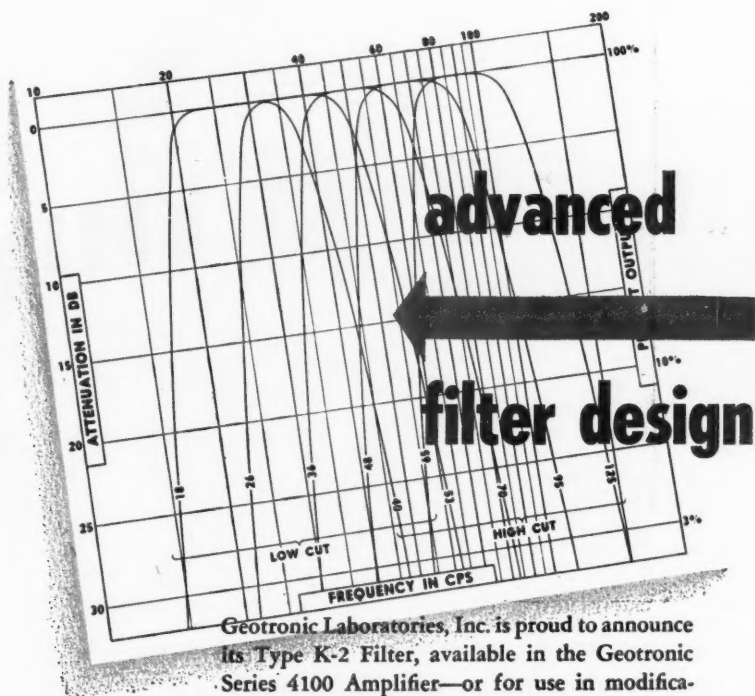
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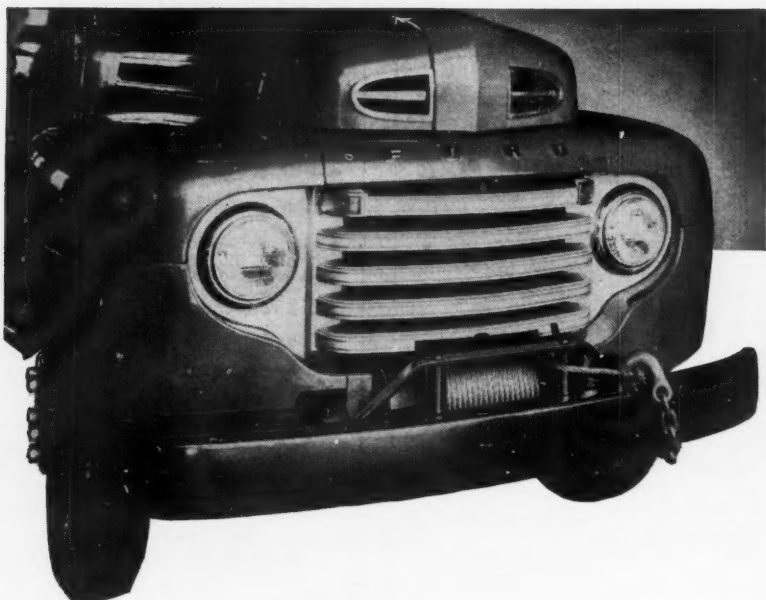
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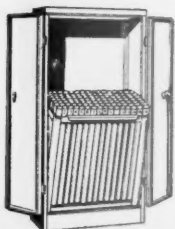
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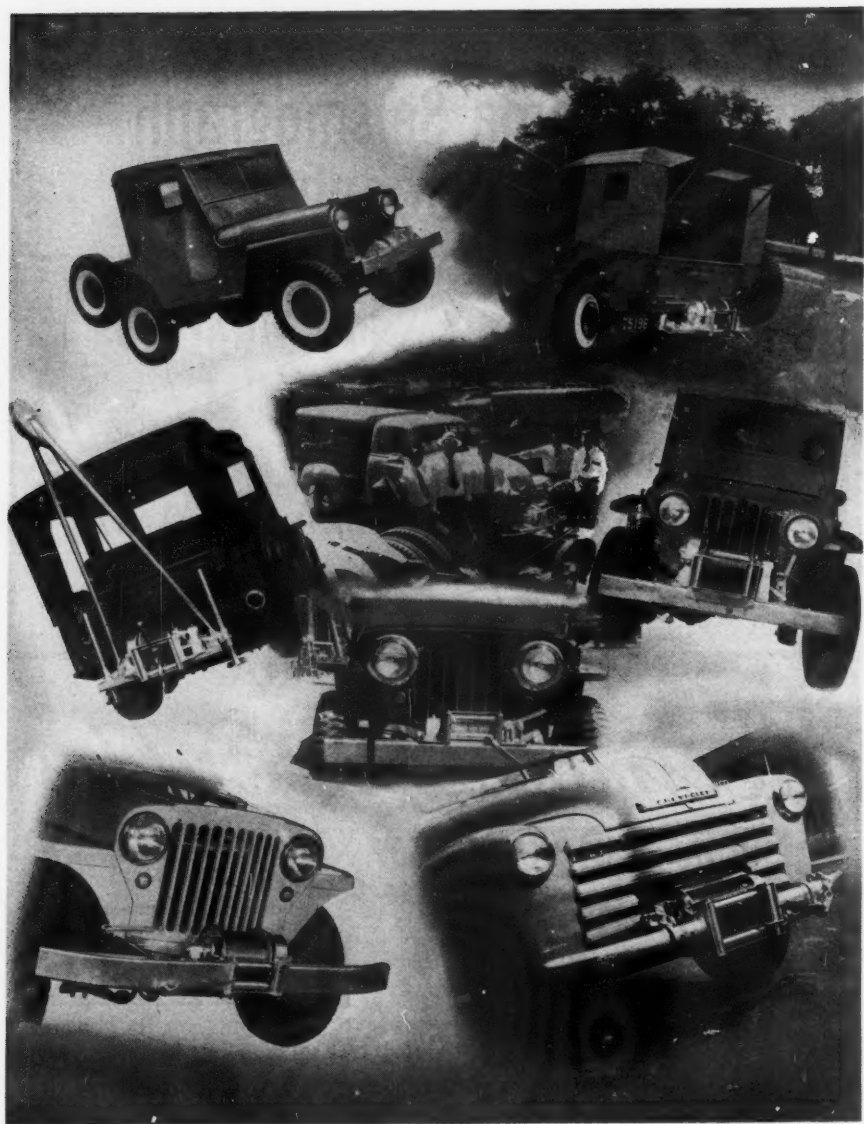
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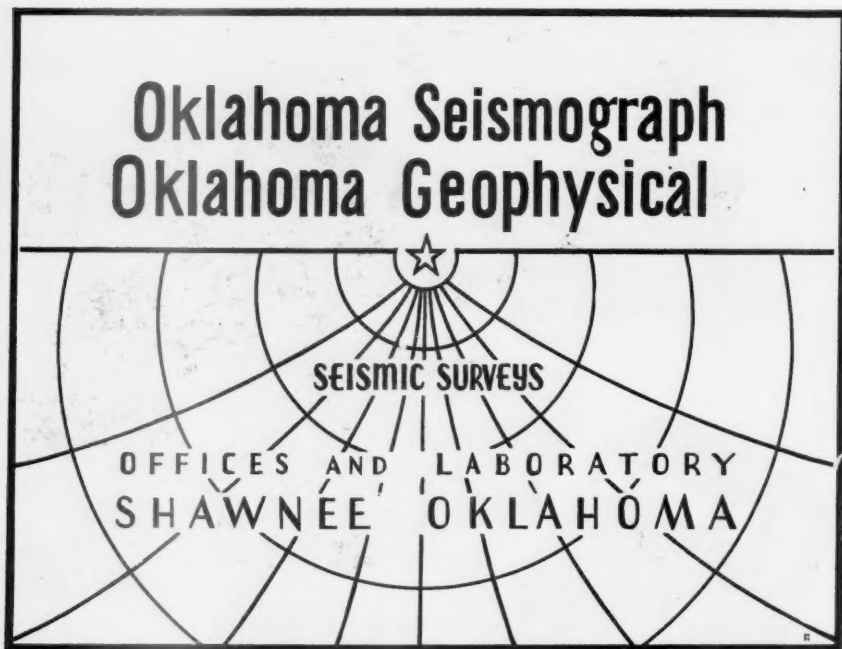
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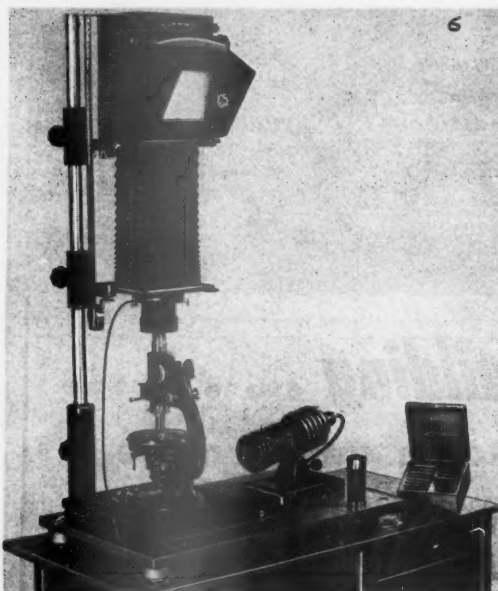
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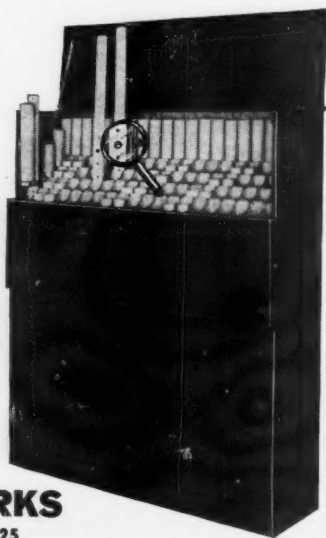
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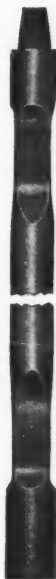
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NO. 2—148 pp. ALA.: Pre-Selma Cretaceous. ALBERTA: Jurassic-Cretaceous. GEN.: Continental shelves. MONT.: Jurassic-Cretaceous. ORE.: Up. Nehalem River. PERU: Reconnaissance. TEX.: Katy field, Waller Co.; Low. Pennsylvanian.

NO. 3—172 pp. ECUADOR: Up. Cretaceous and Paleocene micropaleontology. EUROPE: Carpathian oil fields. GEN.: Porosity through dolomitization; members; financial. NEBR.: Boice shale, Mississippian. WEST VA.: Drill cuttings.

NO. 5—168 pp. ALA.: Vick formation. GEN.: Organic material; Jacob staff; aerial photog.; minutes; college students. KAN.: Buried hills, Barton Co.

NO. 6—264 pp. DEVELOPMENTS. PERU: Geol. TURKEY: Harbolite.

NO. 7—144 pp. GEN.: Science legislation; military service; production engineering; grain roundness. TEX.: Gas reserves; Quaternary. VA.-TENN.: Ordovician.

NO. 8—212 pp. GEN.: Geological directory. KAN.: Siluro-Devonian. MONT.: Ellis, Amsden, Big Snowy group, Judith basin. UTAH: Paleozoic-Mesozoic, Uinta Mtns.

NO. 9—188 pp. ALASKA: Possibilities. FRANCE: Aquitaine basin. GEN.: Quimbys Mill member, Platteville formation, Ordovician; oölite and oöolith. GERMANY: Oil fields. S. AMER.: NW. framework. UNITED KINGDOM: Occurrence of oil.

NO. 11—184 pp. ARIZ.: Faulting, Grand Canyon. GEN.: Faults; spectrochemical logging; grain size; Jacob staff; organic material. N. MEX.-W. TEX.: Permian. N. CAR.: Continental slope. OKLA.: W. Edmond. TEX.: Hawkins, Wood Co.

NO. 12—140 pp. GEN.: Oceans and continents; geological-geophysical trends; drilling statistics. OKLA.: Elmore embayment, Garin Co. S. AMER.: Framework.

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NO. 1—200 pp. AUSTRALIA: Stratigraphy. CANADA: Ordovician, Silurian, Yukon Ter. CUBA: Camaguey dist. GEN.: Stratigraphy, sedimentation. JAPAN: Production. KAN.: Kinderhook dolomite, Sedgwick Co. KAN.-OKLA.: Oil and stratigraphy.

NO. 2—228 pp. ARIZ.: Paleozoic. CALIF.: Fish remains. GEN.: Vertical scale; log map; resistivity and core analysis; altimeter surveying, reservoir fluids. GULF: Diastrophism. MICH.: Cambrian, Ordovician in deep wells. S. DAK.: Jurassic, Black Hills. TEX.: Analyses of basal complex. WYO.: Black Hills; Paleozoic, Park Co.

NO. 3—228 pp. GEN.: Basin structures; aerial photos; diagenesis and weathering; sedimentology; stratigraphic commission; members; audit. MICH.: Traverse group. N. MEX.-TEX.: Permian Castile sea. TEX.: S. Mayes, Chambers Co.

NO. 4—140 pp. GEN.: Continental shelves; evolution of geologic thought; Permian correlations; facies map, log map. GULF COAST: Tertiary; micropaleontology. N. MEX.: Rattlesnake field, San Juan Co. TEX.: Del Monte field, Zavala Co.

NO. 5—120 pp. GEN.: Photogeology in Naval exploration; annual reports and minutes.

NO. 6—264 pp. ANNUAL DEVELOPMENTS.

NO. 7—232 pp. GEN.: Presidential addresses; domestic and foreign development; salt-dome structure; nomenclature; oceans and continents. KAN.: Ordovician limestones.

NO. 8—196 pp. AUSTRALIA: Roma. CALIF.: Ventura Basin. COLO.: Up. Montana group. GEN.: Insoluble residue; clay mineralogy; plane-table; glauconite. MONT.: Devonian. N. MEX.: Comanche, Black R. Valley. PACIFIC: Production. RUSSIA: Reserves. TURKEY: Paleozoic-Mesozoic. WYO.: Oregon Basin.

NO. 9—172 pp. BRIT. COLUM.: Mississippian. CALIF.: Salt Creek. GEN.: Faults. KAN.: Up. Ordovician LA.: Tidal basins. N. MEX.: Triassic, Pecos Valley. ROCKY MTNS.: Jurassic. TEX.: Tidal basins. WYO.: Paleozoic and Mesozoic.

NO. 10—204 pp. ALA.: Black Warrior Basin. COLO.: Freezeout Creek fault, Baca Co. FLA.: Oil. GEN.: Microbial transformation; geomorphology; Cretaceous, SE. U.S.; onlap and strike-overlap; dip computation; perspective diagrams. GULF COAST: Cenozoic. MISS.: Black Warrior Basin. OKINAWA: Geology.

NO. 11—176 pp. CALIF.: Sespe redbeds. COLO.: Pennsylvanian. GEN.: Convergence; diagenesis of brines; steeply dipping oil sands; pore space; Foraminifera. GERMANY: Hannover conference. LA.: Crowley dome, Franklin Parish. N. CAR.: Coastal Plain. TEX.: Ellenburger, Llano Co.; Saratoga salt dome, Hardin Co.

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NO. 2—164 pp. FRANCE: Gas structures. GEN.: Sedimentation and accumulation; core orientation. SIBERIA: Oil. TEX.: Slick-Wilcox field, DeWitt and Goliad Cos. VENEZ.: Maracaibo Basin.

NO. 3—200 pp. GEN.: Stratigraphic commission; members; audit. MO.: Plattin-Joachim zones. U.S.S.R.: Petroliferous provinces.

NO. 4—192 pp. GEN.: Transferring distances on maps of different scale. MICH.: Mississippian Marshall formation. VENEZ.: Oil fields of Royal Dutch-Shell.

NO. 5—142 pp. BAHAMAS: Submarine features. COLO.-KAN.-OKLA.: Hugoton embayment. GEN.: Appal. and Alpine structures. ILL.: Benton field, Franklin Co. MEX.: Ranger Bank. ORE.: Siletz R. volcanics. TENN.: Up. Devonian bentonite. TEX.: Petersburg pool, Hale Co.

NO. 6—360 pp. ANNUAL DEVELOPMENTS. Annual reports and minutes.

NO. 7—184 pp. CAL.: Fractured rock reservoirs. GEN.: Presidential addresses; petroleum in E.R.P.; isopachous maps of sands; geology, 1907-47; survey of students. GULF: Artesian salt. N. D.: Sentinel Butte sh.: OKLA.: Up. Cambrian. W. INDIES: Tertiary Cipero marl; Curacao.

NO. 8—296 pp. APPALACHIAN BASIN Ordovician symposium. CAL.: Ramona field, Los Angeles and Ventura Cos.

NO. 9—160 pp. GEN.: Geologist in uniform; structure and fault systems, East. Interior; gas for future. LA.: W. Tepepate field, Jeff. Davis Parish. MEX.: Jurassic; Santa Rosalia, Baja Calif.

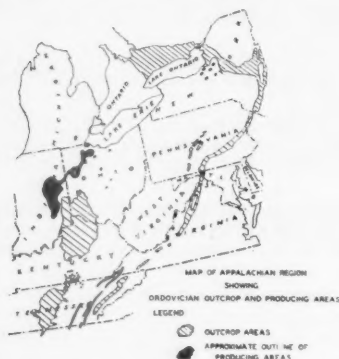
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NO. 11—172 pp. GEN.: Geologic tools. ILL.: Deep drilling. KY.: Hitesville Consolidated field, Union Co. MID.-CONT.: Pennsylvanian. ROCKY MTNS.: Red-banded Cenozoic.

NO. 12—188 pp. CALIF.: Salinas Valley. GEN.: Catalysts in formation of oil; template for spacing contours; scientists and reserve officers; annual index. LA.: Submarine canyon. OKLA.: Fernvale and Viola.

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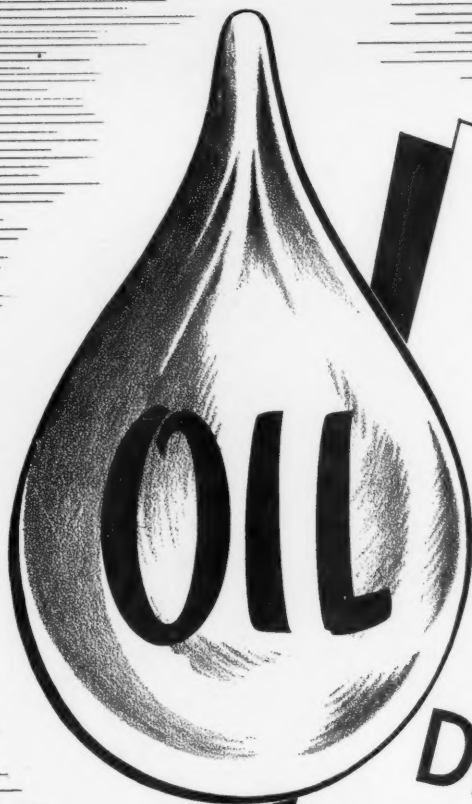
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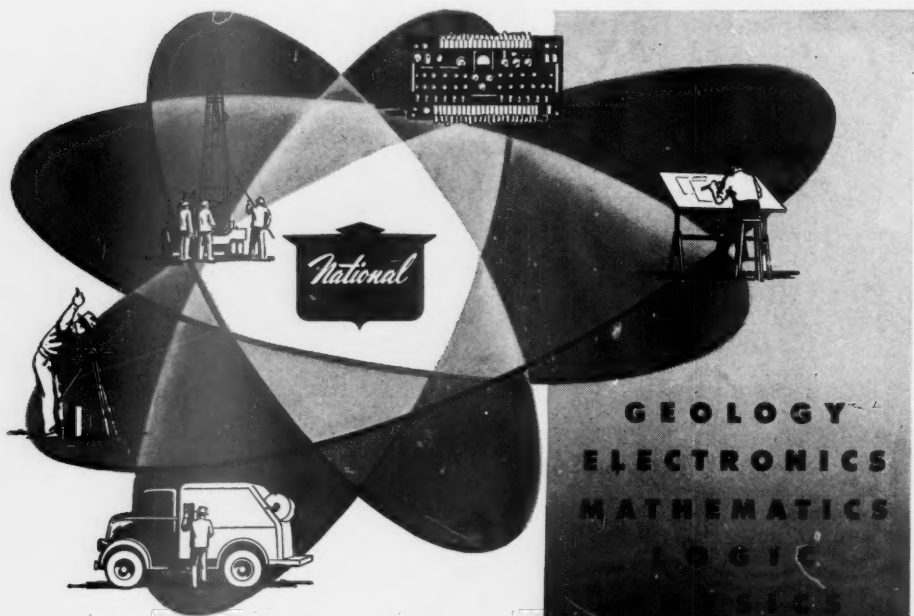
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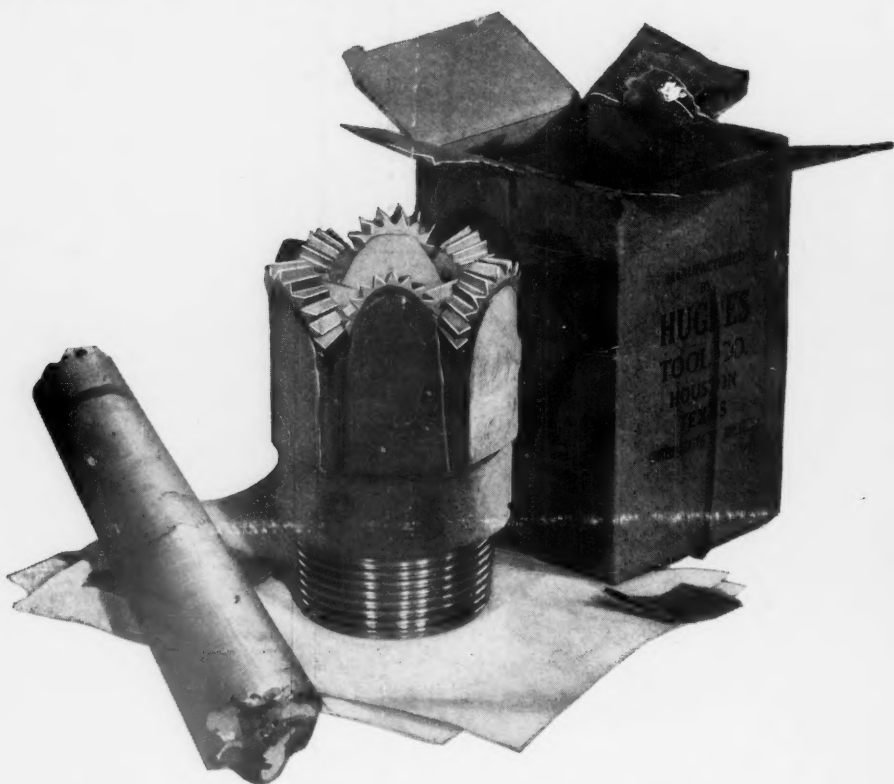
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